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THE WORLD'S GREAT LABOR SAVERS AND LABOR SERVERS.

By Robert W. Hunt.

There are two methods of treating such a theme as is suggested by the title of Mr. Hunt's article. One is the comprehensive historical survey; in so vast a field and so limited a space for record as we have here, the result could scarcely be more than a chronological list. The second mode of treatment is the selection of some typical period or movement, and the restoration of it before our eyes,—the resetting of the stage with the atmosphere of the time it recalls and the living personality of the characters who then played their parts. It is this latter which Mr. Hunt chooses. His special theme is the development of steel-making —a matter which he justly says lies at the foundation of all modern expansion in the engineering industries. His company is that little band of Anglo-American engineers, fertile in creation, bold in undertaking, tireless in energy, marvellous in organization, among whom his own place was more prominent than his modesty permits him to disclose. And his narrative is vital with the life which is given by the intimate bond with the things it sets forth, and warm with its nearness to the great actors (some of them still living) in the events with which it deals.—THE EDITORS.

IT certainly is an inherent quality of the human mind to seek the lightening of whatever manual labor the environment of habitation may require. This has been manifested in all known ages, and the discovered relics of prehistoric man point to the same fact. And it is notable that either the development of these labor-saving devices has brought about an equal elevation of human condition, or else such bettered conditions have demanded, and hence commanded, the devices. At all events they have practically gone together.

It needs no argument to prove that the physical, moral, and mental condition of the tiller of the soil in all civilized countries is far in advance of that of the same class in past generations; and in no occupation has there been greater development of labor-saving machinery. The man preparing the soil for the receipt of grain by the use of a

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sulky plow, has to be a higher organism than he who scratched the ground's surface with a bent stick, or even a grubbing hoe. And the rate of development of the man has been equal with that of the tools used by him. So it has been in all the occupations of life. To write of them all would fill an encyclopedia, and thus go beyond my part in this intended series of articles. Therefore in making my contribution to it, I shall chiefly confine myself to the branch of manual activity with which I have been most intimately associated, and so shall write of the development of labor-saving machinery in the making of iron and steel. In that industry it has been remarkable both in rapidity and results. In fact, iron and steel may be considered as the foundation stones upon which the edifice of civilization rests. Their development and growth have made all else possible.

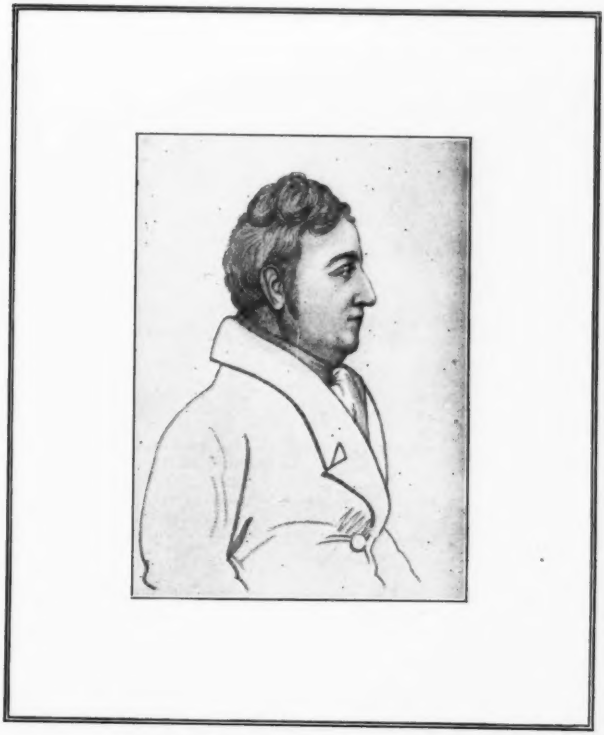
As mankind progressed, the time came when iron became a necessity; its ores were found and in some way its extraction from them discovered. For a long time only the direct processes of obtaining malleable iron were known—this because of their simplicity, and that of the required apparatus. As the use of the metal increased, it was wanted in masses which it was impossible to obtain in that way, even though developments and improvements had taken place. And there was also that never-ending demand for cheaper material. So came the blast furnace, yielding, at less cost, metal in greater quantities, and capable of being formed in larger masses. This for many purposes had to be further treated before being used, but used as a base it permitted results which it was impossible to obtain from the directly reduced product.

Such furnaces required the handling of larger quantities of ore, flux, and fuel, and so naturally led to the invention and perfecting of mechanical labor-saving means of so doing; and each subsequent step forward has accentuated this. No one thing can stand alone; the growth of one affects all others. The early blast furnace had its blast from water-power-driven bellows; the iron ore and limestone and fuel were charged into it by actual hand labor, and its 5, 10, to 30 tons of produced iron carried from in front of it by the same power. The furnace of today receives its burden from automatically handled skips, which have themselves been automatically filled from chutes; and the resulting daily product of 500 to 700 tons of metal is taken away in ladles, while yet liquid, or else mechanically cast into pigs, and loaded upon cars, all with the expenditure of the minimum amount of human labor, and the blast for smelting has been blown by the highest type of steam engines, the latest advance being the replacement of the steam

JOHN SMEATON, F. R. S. 1724-1792.
From Rodes' portrait, National Portrait Gallery. Copyright by Walker & Boutall.
Engineer of Ramsgate harbor, the Forth & Clyde canal, the second Eddystone light-house, and much important bridge work. His chief mechanical work was in the vast improvement of mill machinery and in the great advances he made in the development of Newcomen's steam engine. In this, however, his work was eclipsed by that of Watt.

SIR RICHARD ARKWRIGHT. 1732-1792.

From the painting by Joseph Wright, A. R. A. Copyright by Walker & Boutall. Famous for inventions in cotton spinning—the first great step in powering the textile industries, and one which made cotton manufacture the leading industry of the north of England. Began life as a barber; entered upon his inventive work in 1767, and took out his patent in 1769. Knighted in 1786.



EDMUND CARTWRIGHT, D. D. 1743-1823.

Inventor of the power loom—the second great step in the textile industry. It was suggested to him, he says, in 1784, by his perception of the fact that Arkwright's spinning machinery could turn out more yarn than all the hand weavers of the world could use. His patent was taken out in 1785-7. Inventor also of a steam wheel, a surface condenser, segmental piston packing, and other devices.

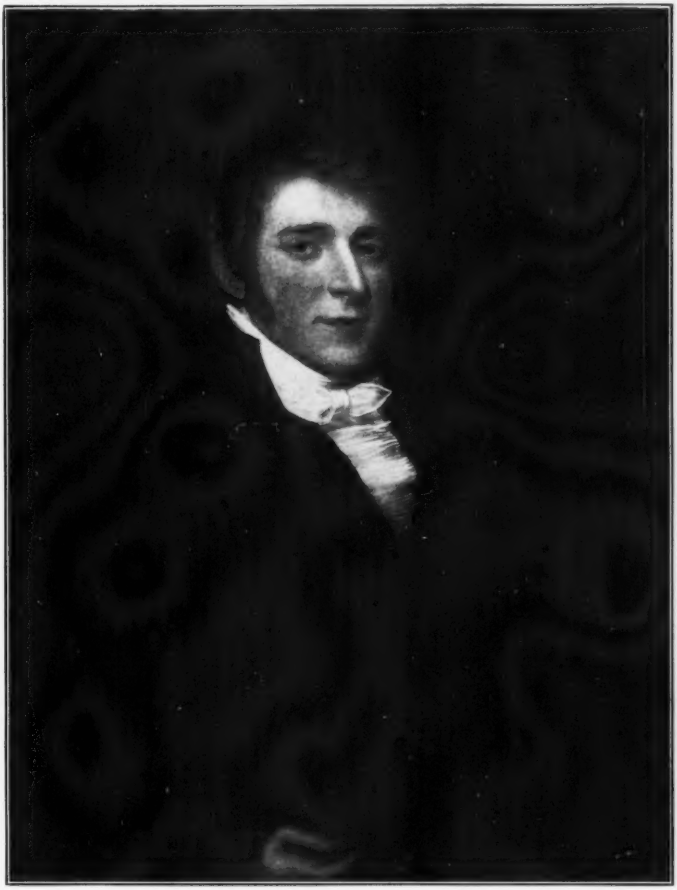
by the furnaces' own waste gas. To produce that 500 tons of iron required at least 1,400 tons of raw material, the supplying of which could be possible only by the use of labor-saving machinery in each step of handling, clear back to where the ore, lime, and coal were taken from the ground.

As stated, iron was first obtained from the ore by direct processes; this put it into the form of blooms which were subsequently forged into bars and other shapes under hammers—originally hand-wielded, but later driven by water power, and still later, by steam. Long before this latter time however, the work of the hammer had been sup-

ELI WHITNEY. 1765-1825.

From a portrait by King. By courtesy of Eli Whitney, Esq.

A high type of American inventive genius. His cotton gin completed the cycle of mechanical inventions which put the textile industry on a firm manufacturing basis. He introduced also the system of interchangeable parts.



ROBERT FULTON. 1765-1815.

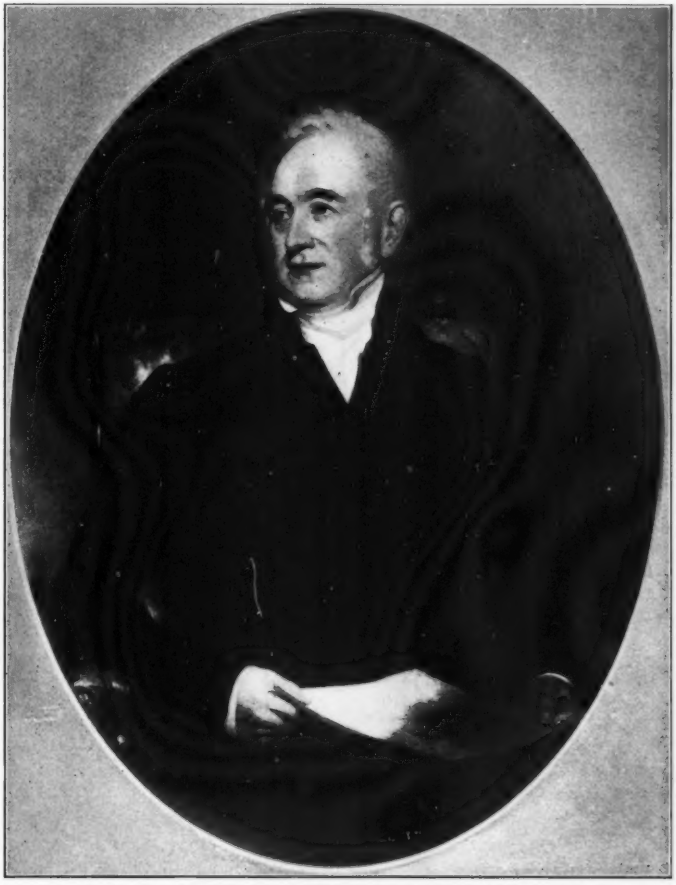
Portrait painted by himself, now owned by American Society of Mechanical Engineers. First distinguished as a talented and successful artist. While in England, as a pupil of Benjamin West, he met James Watt, Lord Stanhope, and the Duke of Bridgewater, father of the British canal system. In 1803 undertook to build a steamboat on the Seine; in 1807 launched the successful Clermont.

plemented by the use of rolling mills, between the cylinders of which the metal was pressed into shape; these also being driven by water power. The elevation of mankind continued and demanded and received the invention of the steam engine, the development of which made possible the location of iron-making plants at points remote from water falls, and thereby broadened that industry.

As communities increased and the demands of living grew, transportation of persons and material became a matter of supreme importance. Roadways and vehicles were improved, until following the invention of the steam engine, came the locomotive and the iron road bed on which it was to run. Remember each of these steps in advancement came slowly, and each gave to mankind increased comfort and individual expansion.

There was much uncertainty as to the kind of road bed which would be necessary for these fire-breathing monsters; but that they must run on metal ways was conceded. At first these were made by simply spiking flat bars of iron upon the tops of longitudinal wooden stringers. Later cast-iron rails were used, and these were followed by wrought-iron ones; but for many years the flat strap rails were the ones in general use. While they permitted what was considered most admirable results, they absolutely prevented greater development in the way of increased speed and weight of rolling equipment. This limitation led to the rolling of wrought-iron rails of various forms—first the bridge or U, and then the T-shaped sections. These latter were designed by Charles B. Vignoles, an English engineer, and Mr. Robert L. Stevens of the United States at about the same date. This brings us to what proved to be an epoch in rail making, and incidentally in the railway history of the world.

The first American rail mill, that is, one built to produce other than strap-iron rails, was the Mount Savage Works, situated in Allegheny County, Maryland, erected in 1843. This was followed quickly by other mills, the enterprises meeting with varying and not always successful experiences. In 1853, the Cambria Iron Works were built in Johnstown, Pa., to manufacture iron rails. The location was selected because of an abundant iron-ore and coal supply; these two minerals being deposited in the same hills, and within a few yards of the selected blast-furnace and rolling-mill sites. There had been preceding iron works in the locality, designed to make other products than rails, but they had passed away. The iron ore which had been used by the earlier establishments, and which led to the building of the Cambria Iron Works, was the outcropping of silicious carbonate. The



GEORGE STEPHENSON. 1781-1848.

H. W. Pickersgill, R. A., National Portrait Gallery. Copyright by Walker & Cockerell.

The son of a colliery fireman. First to apply the locomotive steam engine to railways for passenger traffic. Patented his locomotive in 1815, and constructed the first railway, between Stockton and Darlington, in 1825. The "Rocket" ran in 1830. Chief engineer to most of the railways built during the ensuing ten years in Great Britain.

SIR MARC ISAMBARD BRUNEL. 1769-1849.

From Northcote's painting, National Portrait Gallery. Copyright by Walker & Boutall.

Educated first for the church, then for the navy. Carried on important engineering work —notably the Thames tunnel and the promotion of steam navigation. His significant labor-saving achievement was the design and introduction of wood-working tools for making ships' blocks by machinery.

ISAMBARD KINGDOM BRUNEL, F. R. S. 1806-1859.

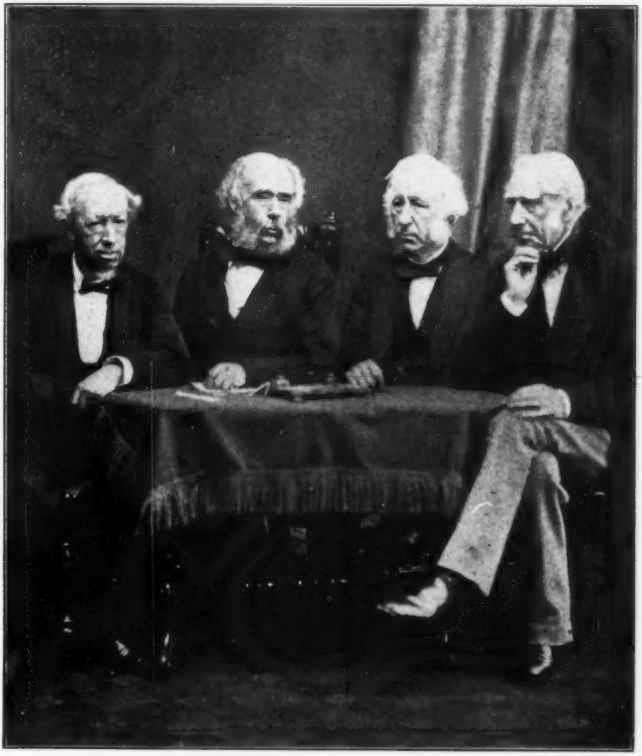
From portrait by Horsley, National Portrait Gallery. Copyright by Walker & Cockerell.

Son of Sir Mark Isambard Brunel, and at first his assistant. He designed the Great Western —the first great ocean steamer—and built the Great Eastern, until lately the largest vessel ever completed. As engineer of the Great Western Railway he was a leading genius in the development of railway transport.

operations of the small plants had been more or less satisfactory, but the consumption of the greater works soon exhausted the outcrop and compelled the use of the leaner ore, which produced iron of inferior quality. When puddled it was both red- and cold-short. While the hardness incident to the latter gave good wearing rail heads, the red-shortness rendered it difficult to obtain finished rails of which the flanges were not so badly cracked that they had to be thrown on the scrap heap.

Iron rails were rolled from a pile composed of a number of bars of wrought iron placed one upon the other, brought to a welding heat in a furnace, and then passed between the grooves of rolls, which welded them together, and gradually elongated and formed the mass into a finished rail. Up to July, 1857, all rails at Cambria and other mills were rolled on non-reversing two-high trains of rolls. That is, there were but two rolls in a set, and as they were driven constantly in one direction, the metal which was being drawn into shape by their grooves could be rolled only in that direction. After each passage between the rolls, the pile, or bar, had to be passed back over the top roll, its revolution assisting in this. Of course quite as much time was consumed in this passing back as in the opposite rolling or reductions. Not only was time consumed and the amount of production limited, but the metal under treatment lost heat, and thus augmented the difficulties in obtaining satisfactory welds of the several slabs of iron composing the rail piles and freedom from "red-short" cracks in the finished rail. The difficulties at Cambria continued to increase, and, with no other available ore supply, were at last so serious that the prospects of the company were gloomy indeed. On this establishment the entire community were dependent, and its failure, and from such a cause, meant their ruin, without hope for the future. But, as has so often and so providentially happened in the world's history, a man arose who was equal to the emergency, and while saving the immediate situation, by his invention of labor-saving machinery, also installed that which was destined to revolutionize the rail industry of the country.

Mr. John Fritz was then the chief engineer of the Cambria Company. I can best describe the situation by repeating what I wrote on a former occasion. His keen mechanical perception and good judgment saw the solution of the problem. It was to save the time and heat lost in passing the bar back in idleness over the top roll; this could be done by adding another or third roll, and so making that which had been the top, a middle one. This top roll, revolving in the opposite direction to the middle one, permitted grooves to be added,



John Penn. Joseph Whitworth. R. Napier. W. Fairbairn.

A GROUP OF LEADERS OF ENGINEERING OF THE EARLIER NINETEENTH CENTURY.

Sir Joseph Whitworth was a pioneer in the building of machine tools, and in standardization in mechanical manufacture. Sir William Fairbairn's early work was in the substitution of iron for wood in machinery, in the economical reduction in weight of shafting and metal sections, and in systematic and scientific testing of materials of construction. Robert Napier was among the first of the steamship builders, and in 1840 furnished the Cunard Company their first four steamers. The portrait was taken at the Manchester meeting of the Institution of Mechanical Engineers, 1866, and the engraving is from a rare original photograph in the possession of the American Society of Mechanical Engineers.

in which the metal could be reduced as it was brought back to the front of the train of rolls. To accomplish this successfully, he invented the Fritz "Yielding Hanging Guides and Driven Feed Rollers." This solution seems now so simple a one. But we must remember that at the time of its conception, rolling mills were considered old institutions, and their designers and managers thought themselves, and were

SIR HENRY BESSEMER. 1813-1898.

From a life photograph in possession of the American Society of Mechanical Engineers.

Began life as a modeller and designer, taking up mechanical processes for replacing manual toil. His pneumatic steel-making process was announced in 1856 but perfected only in 1859. At first ridiculed by ironmasters, it eventually revolutionized the world's materials and methods of engineering construction.

thought by others, to be very smart men. Moreover, there were difficulties in the construction and operation of this proposed mill which would appear only to those possessed of some practical knowledge. Indeed, some of those high in the councils of the Cambria Company entered solemn and official protests against that crazy man, Fritz, being permitted to waste the company's money. Its affairs were badly enough off, as it was, without adding this foolishness.

In addition, some of Mr. Fritz's brother engineers and intimate friends compelled themselves, as a matter of fraternal duty, to labor with him against his folly, and thus prevent his scattering to the winds his most excellent and hard-earned reputation. In spite of all, he had the courage of his convictions, and the new mill was built. It proved a success, and the situation was saved. All the other rail mills in America subsequently adopted the plan. The Cambria Company continued to prosper and has for many years been one of the largest iron and steel producers of the world. The little village of Johnstown has grown into a city of many thousands, and this in spite of a later awful calamity, which caused the greatest disaster to life and property known to civilization.

This labor-saving invention of Mr. Fritz was the basis on which American rail-mill practice grew, and helped forward by other labor-saving inventions of himself, his brother George Fritz, William R. Jones, and others, led to that progress which ultimately placed the United States pre-eminently ahead of the world in rail production. These results have been accomplished only by hard work, and the application of much mechanical and executive ability.

John Fritz left Johnstown in 1860 to become the active head of the Bethlehem Iron Company, at South Bethlehem, Pa., where he continued his labors with the same character of beneficial results for his country and fellow men. A list of his labor-saving machinery would be a long one, and perhaps what will stand as the crowning glory of his career will be his successful introduction into the United States of the manufacture of steel armour. He had the acumen to use the best European designs, but also the ability not only to improve upon them but also from the very first, to make the enterprise a success.

Some years ago, the United States Government thought seriously of establishing its own armour and ordnance works. Mr. Fritz was employed to prepare the plans for it, and to submit an estimate as to its cost, and the price at which material could be produced. When the then Secretary of the Navy presented him to the Congressional Committee having the matter in charge, he said: "Gentlemen, I present

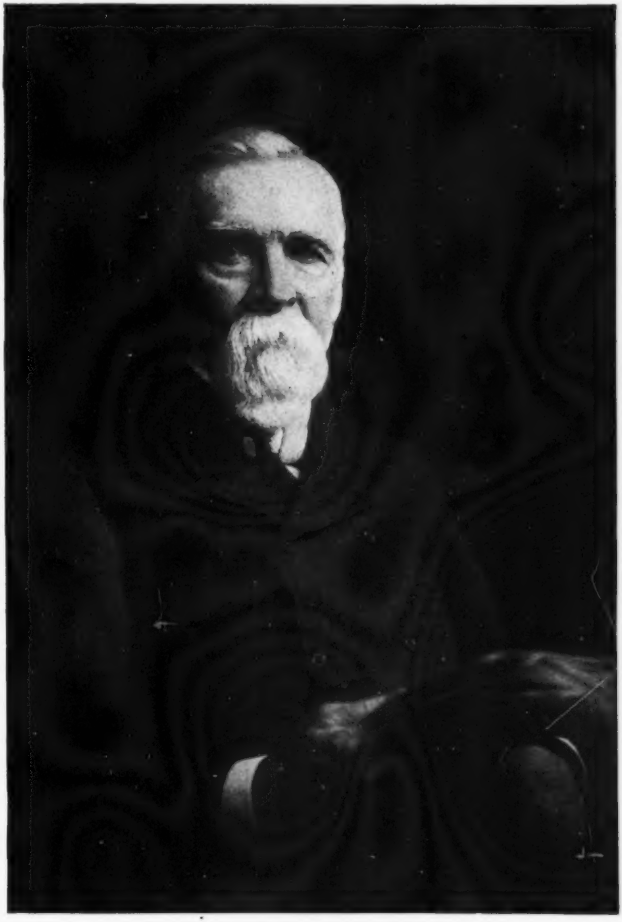
to you Mr. John Fritz, the most honest man I have ever known." Mr. Fritz's days of usefulness are not yet over, and may the world be blessed by his presence for many years to come!

Mr. John Fritz was succeeded at the Cambria Works by his younger brother George Fritz, who while unlike him in many traits, was his counterpart in sterling uncompromising honesty and great mechanical skill. Under his direction, the works continued to grow and prosper. The introduction of the Bessemer process for making steel found him in mechanical and manufacturing charge of the works. As Mr. William Kelly—who had been granted American patents on the process as against those issued to Sir Henry (then plain Mr.) Bessemer—had conducted many of his experiments at the Cambria Works, George Fritz was quite familiar with the subject. Moreover, the Cambria Iron Company had joined a syndicate of American manufacturers in purchasing Kelly's patents as well as Robert Mushet's American one, which covered the step by which the process had been made a commercial success. Daniel J. Morrell was the general manager of the Cambria Company; he was a man of broad mind, and had become thoroughly convinced of the great potentiality of the pneumatic process of steel making. It seems hard to believe now that any one ever doubted, but many did; having among their number some of those who were considered as of the highest authority upon iron and steel manufacture.

I remember hearing Mr. Morrell say to his board of directors, while the question of entering upon the construction of Bessemer works was being discussed, to which some of them were strongly opposed: "You may think me crazy, gentlemen, but if you will pay me the book value for my Cambria stock, I stand prepared to put every cent of it into a Bessemer plant."

While as stated, a combination of American companies had secured Kelly's and Mushet's patents for their country, the American Bessemer patents had been purchased by the firm of Winslow, Griswold & Holley, and naturally there was a legal contest, which threatened not only to cost the parties in interest much money, but also to interfere with the introduction of pneumatic steel in the United States. Mr. Morrell fully realized the unfortunate situation, and it was largely through his exertions that a compromise was reached, and a combination of the conflicting interests.

Ultimately the company decided to build a plant. George Fritz designed this, Alexander L. Holley acting as consulting engineer. But Mr. Fritz was very radical in his views, and while availing himself



JOHN FRITZ. BORN 1823.

One of the foremost agents in moulding the destinies of the industrial world by developing the iron and steel manufacture. His invention and courageous introduction of the three-high rail mill "was the basis upon which American rail-mill practice grew."

GEORGE FRITZ. 1828-1873.

From the only known portrait. By courtesy of John Fritz, Esq.

A pioneer in the American Bessemer process. By his labor-saving inventions he placed himself among the leaders of "that progress which ultimately placed the United States pre-eminently ahead of the world in rail production."

of Holley's advice, made many departures from the designs of any plants built up to that time, and what was more important, designed and built a three-high blooming mill with automatically lifting and driven feed tables, on which to roll the steel ingots.

During part of the time while the Cambria Company was hesitating about erecting the steel works, they had been taking the Bessemer steel made by the Pennsylvania Steel Company, at Steelton, Pa., of which A. L. Holley was in charge, and rolling it into rails at one of their mills which was designed for rolling iron rails, other rolls of course, being used. At first some of the ingots were hammered into blooms at Steelton, and others at Johnstown; at the latter place, under a steam hammer which had been put in some time before to hammer iron slabs to form the heads of iron rails for the Pennsylvania Railroad, in the effort to improve their wearing quality. The short life of iron rails under the increased stress of traffic had caused railway managers much expense, and seemingly brought railway development to a standstill. These steel blooms were then reheated, and as stated, rolled into rails in one of the existing mills. The first ones were produced in August, 1867, on an order from the Pennsylvania Railroad Company, and were the first commercially rolled steel rails in America.

George Fritz concluded that this was not the proper manner of treating the metal. He had blooming rolls prepared, and placed in one set of the rail-train housings. Mr. Holley sympathized with the experiment, and sustained it by having ingots 8½ inches square cast, and sent to him. These were bloomed by the rolls to 6½ inches square, recharged in the heating furnaces, wash-heated, and then rolled into rails. This practice was successful, and I believe this was the first cogging, or blooming mill. Its success led to the final abandonment of the formerly universal practice of first hammering the ingots—a practice which would have made it absolutely impossible for the world's subsequent requirements of steel rails to have been met.

In 1868 Mr. Holley relinquished the management of the Pennsylvania work, and again took charge of the Troy, N. Y., Bessemer Works, which he had originally built. In January, 1871, he started a three-high blooming train, designed from consultations with John and George Fritz. It had lifting tables operated by hydraulic power, but their rollers were undriven, which required the ingots, after being placed on them, to be pushed by hand into the rolls. It required eight men to operate the mill, and was a decided advance.

George Fritz started his Cambria blooming mill on July 10, 1871; the same day the converting works made its first heat of steel. As

already stated, its tables were power-driven, and the number of men required to operate the mill was reduced to four, and its producing capacity increased many fold. In fact, the present typical American blooming mill on which over 75,000 tons of ingots have been rolled in a single month's work, is practically a Fritz mill.

It must be remembered that John and George Fritz and Alexander L. Holley were warm personal and professional friends, which led to frequent interchange of ideas, and their work was always in accord, and without the least taint of jealousy. With three such men, no wonder such tremendous results were accomplished. Unfortunately for the world, George Fritz died on August 5, 1873, mourned by some 5,000 workmen employed by the Cambria Company, as their true friend, and one who had accomplished much in their behalf. I was personally associated with him for thirteen years, and loved him well. I regard him as having been one of the most talented mechanical engineers whom I have ever known.

Sir Henry Bessemer's invention of the pneumatic process of making steel proved to be one of the most revolutionary incidents which have ever occurred in the world's economic history. There have been other great mechanical and metallurgical and other scientific developments, but the steam engine, pneumatic steel, and the telegraph, stand pre-eminently forward.

The limit of railway development, so far as speed of trains and weight of equipment, had been reached. In many places, the stress of traffic was so great that iron rails would last but a few months, and all efforts to increase their wearing quality had seemingly failed. Had such limitations been permanent, it is bewildering to try and realize that which would not have taken place in human progress. But this new way of making metal was not at once accepted as being a success. In fact it was not, until other minds than Bessemer's had worked upon it. Goransson of Sweden did his part in actual demonstration, but most important of all, Robert Mushet discovered the controlling effect of the addition of metallic manganese. Still the commercial world was slow to believe. Alexander Lyman Holley was in Europe at this time, and with his keen insight, was quick to appreciate the importance of the matter, and also what it would in time mean to America. After much persuasion, he succeeded in interesting John A. Griswold and John F. Winslow, iron manufacturers of Troy, N. Y., and the firm of Winslow, Griswold and Holley was formed; representing which, Mr. Holley after much negotiation, secured from Bessemer the United States rights to his patent. Holley at once returned to America and

ALEXANDER LYMAN HOLLEY. 1832-1882.

From a portrait given by his widow to the American Society of Mechanical Engineers. Early associated with Corliss in steam-engine and locomotive work. Entered journalism as an engineering expert, and investigated the Bessemer process in 1863. He threw himself into the engineering problems of this and of the Siemens-Martin and Thomas-Gilchrist processes and played a most influential part in their adaptation and introduction into the United States.

JAMES BOGARDUS. *Iron buildings*
JOSEPH SAXTON. *Fine machinery*
PROF. HENRY. *Electro magnetism*
JOHN ERICSSON. *Marine engineering*
ERASTUS BIGELOW. *Carpet loom*
DR. MORTON. *Anæsthesia*
J. L. MOTT. *Iron work*
F. E. SICKLES. *Steam engines*
HENRY BURDEN. *Iron working*
JENNINGS. *Friction matches*
SAMUEL COLT. *Fire arms*
PETER COOPER. *Organizing of manufacture*
DR. NOTT. *Heating of buildings*
S. F. B. MORSE. *Telegraph*
THOS. BLANCHARD. *Eccentric lathe*
C. H. McCORMICK. *Harvesting machinery*
CHARLES GOODYEAR. *Vulcanized rubber*
RICHARD HOE. *Rotary press*
ELIAS HOWE *Sewing machine*

"AMERICAN MEN OF PROGRESS." FROM AN ENGRAVING PUBLISHED BY THE SCIENTIFIC AMERICAN IN 1861, REPRODUCED HERE BY THEIR COURTESY.

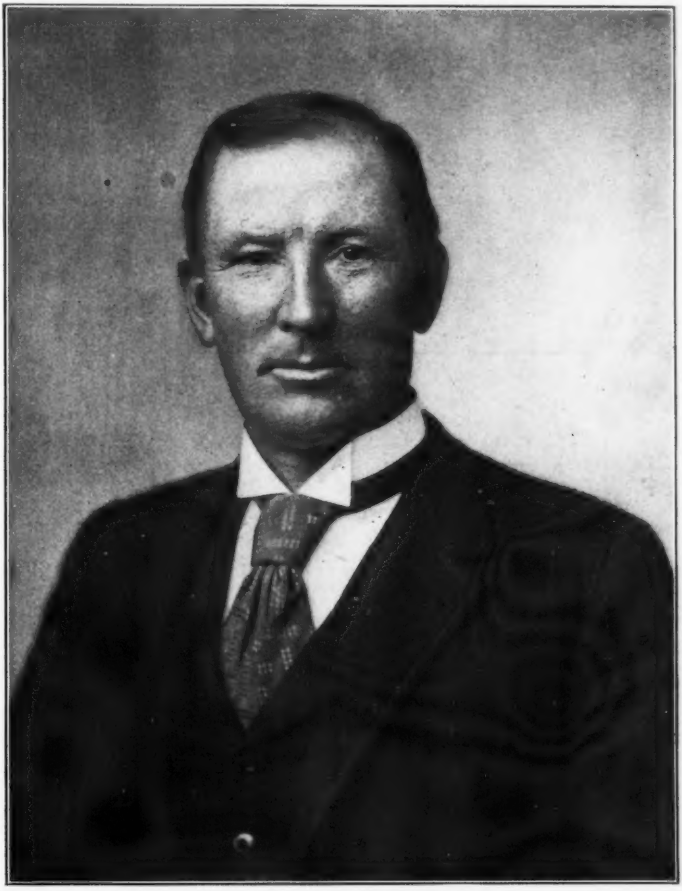
erected an experimental plant at Troy, N. Y. I have previously alluded to there having been a patent conflict between the Kelly and Bessemer interests; while this was pending, Holley's hands were somewhat tied, but his brain was busy, so that when the trouble was happily settled, he was prepared to enter at once upon that brilliant career in connection with America's pneumatic and open-hearth steel industry, which gave to him such fame and to mankind so much good. Accepting the metallurgical conditions, Holley at once attacked the mechanical ones. He did away with the English deep pit and raised the vessels so as to get working space under them on the ground floor; he substituted top-supported hydraulic cranes for the more expensive counter-weighted English ones, and put three ingot cranes around the pit instead of two, and thereby obtained greater area of power. He changed the location of the vessels as related to the pit and melting-house. He modified the ladle crane, and worked all the cranes and the vessels from a single point; he substituted cupolas for reverberatory furnaces, and last, but by no means least, introduced the intermediate or accumulating ladle which was placed on scales, and thus insured accuracy of operation by rendering possible the weighing of each charge of melted iron, before pouring it into the converter. These points cover the radical features of his innovations. After building such a plant, he began to meet the difficulties of details in manufacture, among the most serious of which was the short duration of the vessel bottoms, and the time required to cool off the vessels to a point at which it was possible for workmen to enter and make new bottoms. After many experiments, the result was the "Holley Vessel Bottom," which, either in its form as patented, or in a modification of it as now used in all American works, has rendered possible, as much as any other one thing, the present immense production.

At different times he was in direct charge of the Troy and Pennsylvania steel plants, but in time his services were extended as consulting engineer to practically all of the Bessemer plants of the country. He built the two Troy, and completed the original Pennsylvania works; was consulting engineer during the construction of the Cambria, North Chicago, Joliet, St. Louis, Edgar Thomson, and Bethlehem plants, and was finally employed as consulting engineer by the Bessemer Association, composed of all the American Bessemer Companies.

The inventions of Thomas and Gilchrist made possible the dephosphorization of the iron in both the Bessemer and open-hearth processes, and early enlisted Holley's appreciation. This and the other developments in the Siemens-Martin or open-hearth steel mak-

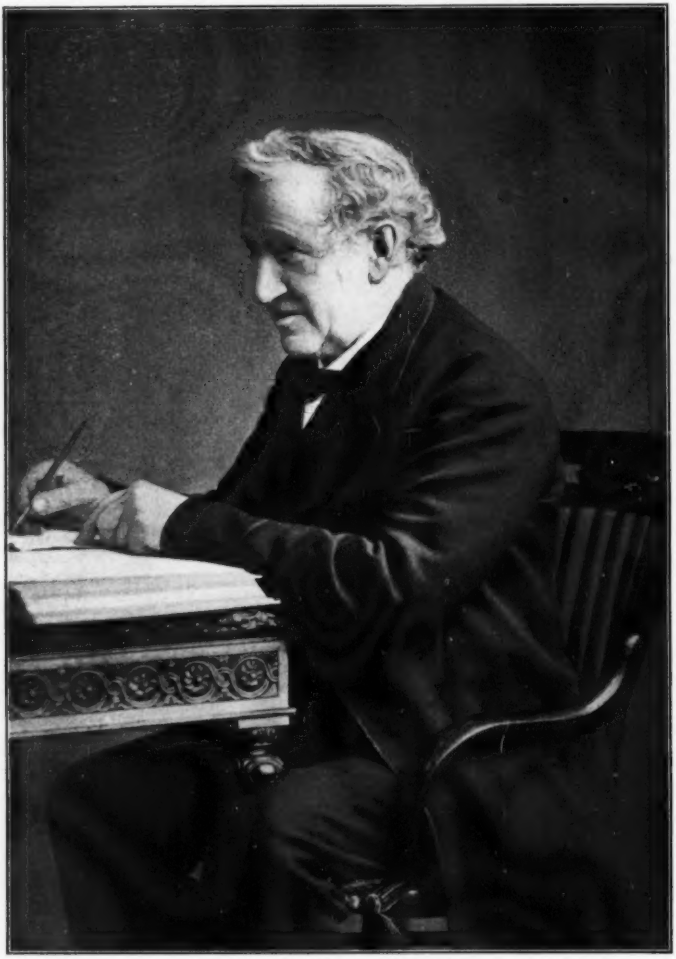
ing, convinced him of its great future, and he persevered in his efforts to enlist the interest of American manufacturers; indeed, he went so far as to predict that in time the open-hearth would supplant Bessemer steel in America. This has not yet occurred, but the increase in the production of the former has fully kept up with the latter, and the fulfillment of his prediction looks much more probable than when it was made. It would be impossible to reproduce today the conditions existing from 1865 to 1882. The country was much younger than the number of years which have passed since then seem to represent. Any one who has not lived through them cannot appreciate the tremendous changes which have occurred; and in no way have they been greater than in the iron and steel business. In 1866—the year following the close of the civil war—there were 1,205,663 gross tons of pig iron produced in the United States. In 1902 were made 17,821,307 gross tons of pig metal, including speigeleisen and ferro-manganese; 6,512 gross tons of iron, 2,941,421 gross tons of steel rails, with a total production for the year, of 9,138,363 gross tons of Bessemer, and 5,687,729 gross tons of open-hearth steel.

The civil war had cleared the political atmosphere, and its experiences had developed a generation of active, aggressive men. There were then fewer iron and steel works and new fields of development presenting themselves; of those, the most attractive was the Bessemer with Holley as its champion. Those who knew him can alone realize how wonderful was his magnetism; how while of all men he was manly, there was still a personal charm that was almost that of a woman. Crowning all were talents granted to few. He was Holley —no man has been like him. It was no wonder that such a man enlisted the enthusiasm of all the young men connected with the various companies, and others with whom he came in contact. Robert Forsyth, P. Barnes, D. N. Jones, Owen Leibert, John E. Fry were among them. There was one other, Captain William R. Jones. He came out of the civil war with the rank of captain after having originally enlisted as a private. On returning to his home, Johnstown, Pa., he resumed his trade of machinist to be appointed almost at once by George Fritz as his mechanical assistant. As such he remained until Mr. Fritz's death; after which he went to the Edgar Thomson Steel Works, which were then being erected near Braddock, Pa., by a company in which Mr. Andrew Carnegie was interested, on plans drawn by Holley; P. Barnes being the resident engineer. Holley had no more devoted admirer than Captain Jones, and he took up his new work with great enthusiasm. Upon the completion of the plant, he



WILLIAM R. JONES. 1839-1889.

At fifteen was earning journeyman's wages as a machinist. At the close of the U. S. Civil War, returned to the Cambria Iron Co. as assistant to George Fritz; later was with Holley, who was consulting engineer to the Associated Bessemer Mfrs. In 1888 became consulting engineer to all the Carnegie companies. The best practical administrator in the American steel industry.



JAMES NASMYTH. 1808-1890.
Mechanical engineer; inventor of the steam hammer and steam pile driver, but particularly identified with the development of the machine-tool industry in England. From an autograph portrait in the possession of Mr. H. H. Suplee.

was made its superintendent, and a record-breaking career for man, plant, and company began. Captain Jones was rugged, fearless, and with an honesty almost chivalric. Certain of himself, he did not hesitate to state truths, no matter to whom, and his individuality was such that respectful attenion was accorded him. The mechanical features of the business appealed most to him, and he was afforded by his company ample opportunity for applying his ideas.

It happened to be my fortune to introduce automatic tables attached to a rail train in the mill of the Albany & Rensselaer Iron & Steel Company, Troy, N. Y., in March, 1884. These were further developed and improved; in all of which work I was assisted by Mr. Max M. Suppes, then the master mechanic of the works, and now the general manager of the Lorain Steel Company. This plan to decrease labor and increase output had been discussed by many, but I believe never actually applied up to this time. Holley used to say in that spirit of prophetic jest so constant with him, "that the day would come when we would start a rail mill on Monday morning and then go home after locking the doors, only returning each morning to count the rails that had been made during the preceding twenty-four hours, no other manual labor being necessary." This point has never been reached, but through these tables and their subsequent perfection by Captain Jones, Robert Forsyth, F. H. Treat, and others, the number of men necessary to operate a rail train has been reduced from 15 or 17 to 5, and the monthly production of rails increased from 15,000 to over 50,000 tons.

A few years after this, Captain Jones built a new rail mill for the Carnegie Company, in which he introduced improved tables and several other labor-saving improvements. It had long been desired to use iron in the Bessemer converter, taken direct from the blast furnace, and thus save the labor and cost of remelting, as well as the heat of the liquid metal. While this was done, it was only successfully accomplished in Sweden, where the amounts handled were small, and the iron of very high quality. It was found in larger practice that the metal tapped from the same furnace at different times, and from several furnaces at the same time, varied so much in its composition, that the results were unsatisfactory. Captain Jones built an immense refractory-lined reservoir—or as he called it, "mixer"—into which the liquid iron was transferred as it was taken from the various blast furnaces, and some 150 tons accumulated and mixed. From this mixer, which was suspended on trunnions so that it could be tilted, the metal was taken as wanted for use in the converter. This gave uniformity

ELIAS HOWE. 1819-1867.
Inventor of the sewing machine; it lightened labor and founded new industries.

CYRUS HALL M'CORMICK. 1809-1884.

From his best photograph. By courtesy of Mrs. McCormick.

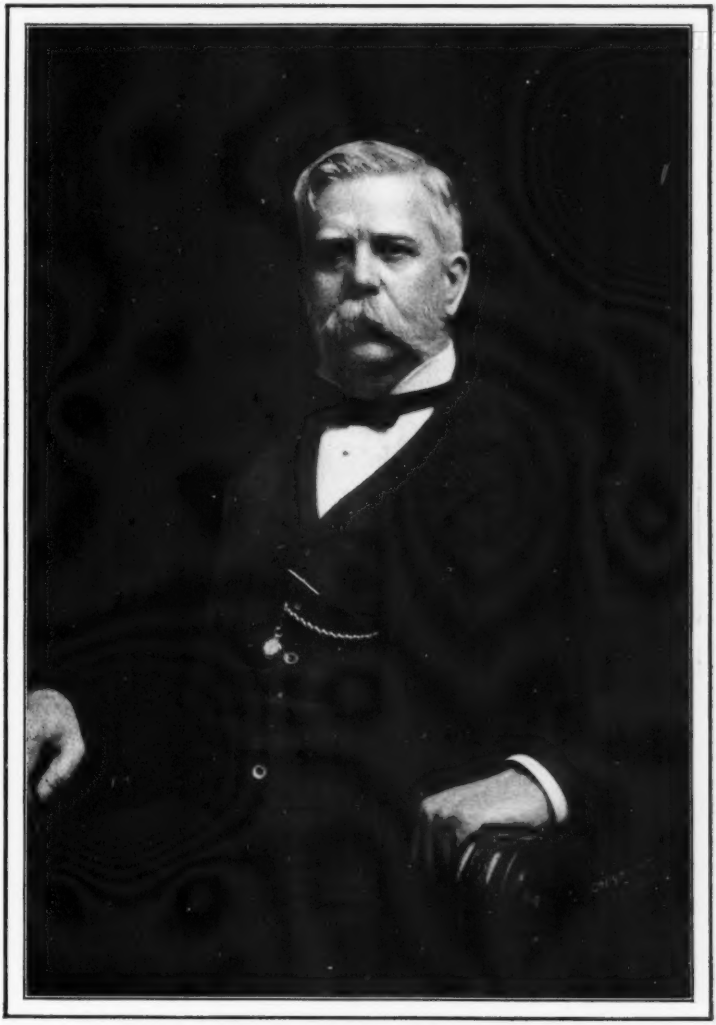
His reaping machine was invented and successfully operated in 1831. It was the first organized appliance for the purpose, and its practical devices have been incorporated in every machine made since. He extended labor-saving methods into the field of agriculture, cheapening and bettering the food of the world.

to it. This plan is now generally used, both in America and Europe. Captain Jones patented the idea, which patent he transferred to his company. Since his death its validity has been attacked, but the United States Supreme Court has sustained his claims. Like George Fritz and Holley, Jones was cut off in full vigor; his death being a tragic one, caused by an explosion at one of the company's blast furnaces.

I have already referred to the great improvements which have taken place in blast-furnace practice. The use of hot blast was a distinct step of progress, and the replacing of the cast-iron stoves for this heating by Whitwell's invention of fire-brick ones, which have since been modified by several inventors, was another great advance. These and the other improvements have all meant labor saving, and not only directly, but through many indirect channels. Among other important developments in the steel business has been that of wire-rod rolling, and the products finished from them. The first signal improvement, certainly in the United States, was made at the Washburn & Moen Manufacturing Company's Works, Worcester, Mass., where a continuous wire-rod mill, after the design and patents of George Bedson of England, was installed. At first this mill was not a success, as iron billets were treated, and that material would not withstand the strain from pulling between the continuous pairs of rolls. Fortunately, about this time Bessemer steel came into general use, and it was found that with it the continuous system was practical.

Mr. Charles H. Morgan was the engineer of the works, and had for his assistant, Mr. F. H. Daniels. These gentlemen greatly improved the system, and made it in every way successful. There were other forms of continuous rod mills, but the Worcester ones and those afterwards constructed at other works, based on the same lines, have been the prominent ones in America.

Perhaps the system of wire-rod rolling which has done the most to revolutionize the business, has been the Garrett mill. In 1882, William Garrett built his first mill for the Cleveland Rolling Mill Company, Cleveland, Ohio. Since then a number of others have been built in different parts of the United States, and their tonnage of production has been astonishing. These largely automatic (and therefore labor-saving) mills have rendered it possible to furnish the farmers with their cheap fencing, thus permitting the enclosing of acreage which under other conditions would have been impossible. Mr. William Garrett, himself a Scotch rolling-mill workman, came to the United States to take a job as roller in the works in which he afterwards was



GEORGE WESTINGHOUSE. BORN 1846.

His work in the invention and introduction of the air brake and of railway signalling apparatus alone has revolutionized the conditions of travel, and made possible an enormous expansion in the railway transportation service. His further work in the development of steam and electric machinery has exercised almost as great an influence in enlarging the scope and bettering the conditions of industrial employment.

EMINENT MEN OF SCIENCE LIVING IN THE YEARS 1807-1808. FROM A GROUP IN THE NATIONAL PORTRAIT GALLERY.

The figures of most interest to the engineer are: 4, Sir Samuel Bentham, civil engineer and naval architect; 5, Matthew Boulton; 6, Joseph Bramah, machinist; 8, Sir M. I. Brunel; 9, Dr. Edmund Cartwright; 12, Samuel Crompton, inventor of the spinning mule; 13, John Dalton, chemist; 14, Sir Humphrey Davy; 16, Bryan Donkin, mechanical engineer; 17, Earl of Dundonald, naval engineer; 18, Henry Fourdrinier, paper maker; 26, William Jessop, civil and hydraulic engineer; 27, Henry Kater, maker of fine instruments; 30, Henry Maudslay, machine-tool maker; 31, Patrick Millar, inventor of paddle steamboat; 33, William Murdock, steam engineer and inventor of gas lighting; 36, John Rennie, engineer and architect; 37, Sir Francis Ronalds, inventor of electric telegraph; 38, Count Rumford; 40, Earl Stanhope, mechanical inventor; 41, William Symington, pioneer in steam navigation; 42, Thomas Telford, civil engineer; 45, Richard Trevithick, pioneer of high-pressure steam-engine; 46, James Watt. Photograph Copyright by Walker & Cockerell.

superintendent, and in which he put his first patented mill. He subsequently designed many other mills, and acquired large pecuniary reward. His death occurred in 1903. He too, was a forcible character. There have been many men engaged in the accomplishment of the great results which I have so briefly outlined. I have particularly mentioned some, not because they are alone entitled to credit, but because at least four of them can be classed as leaders whom any army would be proud to follow.

I have confined myself to iron and steel, but while their development may have been the basis on which other progress has rested, it must be remembered that in those other fields great work has been done. In fact, there is not a line of scientific and practical development on which the world has stood still; and where it has been a practical application of scientific knowledge, labor-saving appliances have always been part of the successful accomplishment.

Comparison of the general condition of the inhabitants of the United States at the beginning of the period covered by my narrative, during that period, and now, will demonstrate that there has been a progressive improvement, and that the standard of living has been raised. If the spirit of unrest has also increased, it is because the people have learned to want more, because it has become possible to have more. No great economic changes of any kind can occur without inconveniencing some one; but if by such disturbances, the many gain at the expense of the few, the ultimate result must be for the good of all. It may be hard lines for the time on the few, but let us remember that a patriot declared ages ago: "It is sweet to die for one's country." Of course so dying did not take away the pangs of dissolution, but there was a satisfaction of duty done, which made even death welcome. So instead of bewailing conditions which may for the time seem to be against our particular case, remember that such changes have been occurring since humanity existed, and instead of hopelessly repining, seek to see and take advantage of the way by which we too may be benefitted.

THE EFFECTS OF LABOUR-SAVING MACHINERY.

By Frank H. Rose

It is scarcely necessary to point out that unless the workman is willing to develop to their best the labour-saving powers of the machine he tends, the genius of the inventor has been spent in vain. The early history of the use of machinery is one long record of the workman's bitter and violent struggle against its adoption. This was followed by the still lingering trade-union effort to limit production, which was merely a newer form of the same false idea. But the growth of mechanical production has been scarcely less remarkable than the growth of the horizon of the better class of labour leaders. Mr. Rose is an exponent of the best and most influential element in British trade-unionism, and his position as defined in the following paper is characteristic of the modern British labour party. It would be difficult indeed to frame a sounder economic philosophy than Mr. Rose professes, or to argue it more ably. The country whose workmen are guided by such counsel as this need fear little from any industrial competitor.—THE EDITORS.

IT would be affectation on my part to deny that my sympathies are with my class. No amount of sympathy, however, can bind me to facts which the most casual student of British industrial history can find lying upon its surface. In dealing with so important a subject as the present, a writer must divest himself of those prejudices which are too frequently associated with class advocacy. For my own part, I am seriously trying to examine the question in a purely non-partisan spirit, and with a desire to exhibit truths rather than to ventilate opinions.

Machine appliances have revolutionised every industry; but in almost every case their best results have been minimised and their natural development impeded—either by the workmen's hostility, or the employers' narrow conception of their possibilities. The most ardent defender of trade-union methods would insult his own conscience by pretending that a heavy share of culpability is not associated with the workman himself.

I am frankly taking the position that machine appliances are not only blessings in themselves, but are the source of manifold benefits to all men. In considering the question I shall have to deal with the "Effects of Labour-Saving Machinery" in its broadest sense, and not merely as it affects my own trade; for antagonism to machinery is not peculiar to operative engineers. Whenever in the history of labour in Great Britain we find manifestations of the workers' opposition to the machine, the root cause is the same. There is no essential difference between the anarchic excesses of the old Luddite, and the subtle method of the modern "reluctant." In one case the hated machine is destroyed; in the other its benefits are sterilised. I am more anxious to find an explanation for this folly than to invent an excuse for it. It undoubtedly arises from a fundamental misconception. The "Luddite" method may be taken as far more defensible than any form of "ca' canny." To the uneducated operative of the early part of last century, the machine was a malignant and insatiable monster which had already devoured his brother and would devour him in turn. He had none of the evidences before him of the benefits which have come to the world as the result of machine processes. The machine was apparently a device of his immemorial enemy to starve him and to slay his calling. He acted upon the first impetuous impulse of ignorance and hatred, and took the impotent course of trying to wipe out his foe by violence.

In front of the workman today are all the vivid proofs of the uselessness, as well as the mischief, of resistance to the inevitable. However unpopular may be such a declaration, I know that no honest enquiry into this question is possible which does not take cognisance of the prejudice which still exists in the workman's mind against new appliances for increasing labour's productivity. Whatever may have been the outward manifestations of this prejudice, their results have been uniformly mischievous, and consistently productive of strife and waste. Yet the growth and development of the machine system is as certain and remorseless as death. No attempt to resist it has ever been crowned with even a temporary success.

Having said so much, I shall be acquitted, I trust, of any desire to colour this article to suit the worker's taste. As an active Labourist with twenty-five years of trade-union effort to my record, I have felt that my own experience enabled me to speak with some degree of authority. In this case, however, I have been at some pains to supplement my own knowledge with the testimony of leading employers and workers. Taking as a basis of enquiry the candid admission that

the prejudice against machinery *does* exist, I have tried to determine its present intensity and influence. From every person I have consulted comes the evidence that the prejudice is passing, however slowly, away. We Britishers are proverbially slow to learn. A natural reverence for tradition makes us cling to many fallacies, not because they are fallacies, but because they are hoary. But it would be strange indeed if even British workman were unmoved by the accumulating evidence of the folly of resistance to the inexorable development of machinery, or the equally unevadable proofs that it has brought a blessing and not a curse.

The policies of the great labour unions are conceived and carried out in a spirit of tolerance and concession towards labour-saving appliances. This would be impossible if a more tolerant spirit were not prevalent with the membership. In spite of all that is said to the contrary, the policy of a "council" is the reflex of the sentiment of the members. Hence it is that in the engineers' unions the "machine question," which for years was the prolific source of dissension and conflict, has practically ceased to trouble. Though the old delusions linger, the consciousness grows that the machine has come to stay and cannot be pushed out. As a result we have the first happy indications that the only rational way of dealing with the machine is to make the best of it. The employers' representatives to whom I have spoken generally admit that the workers are more amenable now than formerly—even recently—and that their own workshop administration is interfered with in a constantly lessening degree by disputes about machinery. I should be glad to be able to say that the old evil is extinct. But I am glad to say that it is perceptibly yielding to a more enlightened and hopeful state of mind.

The British employer, on the other hand, is neither a blameless saint nor a suffering martyr in connection with this question. While he has hung onto his old-world methods and beliefs, he has been forgetful of the fact that the workman's prejudices are more the results of heredity than deliberate ill disposition. Nor has his conception of the machine been one whit more liberal than that of his employee. The machine, I fear, has been regarded less as an agent for increasing labour's value and productivity than as a convenient implement for curtailing labour's reward. The unity of interest between capital and labour has long done duty as a pious opinion—even as an abstract economic proposition. But when we translate "capital" into "capitalist" and "labour" into "labourer," the unity of interest ceases to have any force or value. There is nothing so certain as the fact that so

long as capital works for profit and labour for wages, both will work for their own ends with more or less disregard for each other's interest. The machine appears to me to provide a medium by which both ends may be served if both parties will settle down to make the best possible use of it. We may leave the allocation of blame due to employers and employed respectively an open question, but we have to admit that, whoever deserves the larger share, the machine so far has not had a fair field for its natural development in Great Britain. Yet, in spite of this, the benefits it has conferred are almost incalculable. I cannot trace a single social or industrial evil to its use. I can trace many to its misuse. I regard the machine as the first potential of all the material progress of our age. I am in favour of a frank recognition of its virtues by the workman, and of his endeavour to get its best results. If any words of mine will tend in a remote degree to remove what lingers of the old and stupid fallacy that "Machinery murders Labour," I shall not have written in vain.

The Effects of Machinery on Wages.—I have frequently said to English engineers that there is but one labour question—the question of wages. Whatever complexities we discuss as industrial topics, the question of wages or reward is the one we find ourselves returning to in the end. The only incentive to work is its reward. We occasionally hear of pure-souled and unmercenary persons who need not work, but who do work because they love work. These are valuable communal assets as they serve as shining examples to the rest of us who are fashioned of common clay. There are not many of them. The operative has no other object in working but his wages. If it could be proved that the use of machinery increased his wages, his objection to it would be removed. I do not think that the introduction of labour-saving appliances has had the effect of increasing the *amount* of wages in the country. What it has done has been to increase the purchasing power of a man's wages. Comparisons between wages paid to hand workers fifty years ago and wages paid to machine workers in the same industry today are worthless. The textile trades are those in which this comparison is the strongest. But wages have been raised and maintained by the action of the trade unions, and with or without highly developed machine systems of production, the rule holds good that the best organised bodies of workers are the best paid. What machinery has done has been to cheapen commodities of daily use and so to raise the actual labour value of operatives.

On Hours.—Here again the advantages resulting from machinery

are of an indirect character. The long hours prevalent in the middle of the nineteenth century were due entirely to the lack of power of the workers. No conceivable development of machinery would have any effect in the direction of shortening hours. I cannot find that machinery has increased either the worker's wages or his leisure. But it has enlarged his opportunities for the profitable use of both. It has given him cheap and rapid transit and has enabled him to engage in pursuits and to cultivate tastes which would have been inaccessible without its aid.

On Volume of Employment.—It is in this particular that the effects of labour-saving machinery have been the most pronounced and the most beneficial. It is singular, too, that, though the evidences of this are the most obvious, the worker still regards the machine as a rival and an enemy. The fear is based upon the grotesque hallucination that there is only a certain amount of work to do in the world, and that if machines are employed to do it there will be no work left for the men. It finds its parallel in the crazy "wage-fund" theory of the old economists which set up the preposterous proposition that there is but so much wealth available for labour, and that a rise of wages in one trade or locality must inevitably be followed by a corresponding decline elsewhere. Time and better sense have exploded the "wage-fund" doctrine, but the other and more pernicious fallacy is with us yet. All the facts are against it. Machinery has increased the volume of employment in every trade, doubled it in most, and multiplied it indefinitely in many. It should be superfluous to quote examples. The case of the textile trades is too familiar to need elaboration. The evils which followed the early introductions of power appliances were due not to the use of machines, but to their abuse by callous factory lords in a hurry to get rich. More apposite and more modern is the comparatively recent revolution in the printing trade. The introduction of the linotype was vehemently resisted by the operatives. Then, as ever, resistance was impotent. The thing was there and has stayed there. It was to kill the hand "comp," and to extinguish the printing industry. It did neither. It created a new calling. It widened the possibilities for employment of those already engaged in newspaper work particularly, without lessening either the importance or the possibilities of the printing trade generally. I do not propose to enter into a justification of the thousand and one peculiar publications for which this revolution in the printing trade is responsible. I am treating the question from the utilitarian rather than the ethical or intellectual standpoint. My point is that the world is richer and the worker

no poorer as a worker. As a citizen and a consumer, he is better off with the machine than without it.

On the Standard of Material Comfort.—A race of men and women who wear machine-made raiment, eat machine-made food, and shelter in machine-made houses, need not quarrel with their universal provider. To say that there are just as many naked, starving, and homeless people as ever is no answer to those who assert that the machine has enormously raised the standard of material comfort for the people. Machines will not settle social problems. Acts of Parliament devised by pure and inspired legislators fail sometimes. The man who has no penny is always with us, but the machine has not made any more of *him*. The machine has enabled the man *with* a penny to get for his penny a bigger or a better something every time. If the machine gives us better penny-worths without diminishing our opportunities of getting pennies, the machine must be a benefit. I am not attempting to speak for lands I have never seen, or people I have never known. But I have known something of working-class life in England for the last thirty years at least, and I say fearlessly that the standard of material comfort has risen enormously. With equal confidence I attribute the betterment to machine production. Wages have never risen to an extent which accounts for the difference. In the matter of food it is fashionable just now in this country to ignore the machine as a factor in cheapening the people's bread. But this is the way of politicians. If the crop of a big western farm had to be sown or reaped by hand it would make a bigger difference to our baker's bill than a good many "fiscal reforms."

Our clothing is a machine product from the raw material to the finished garment. We are better dressed than our fathers and there are many more tailors. But in our homes—I speak of workers' homes—the difference between what was and what is, is even more marked. There are a hundred objects common to worker's homes today which were unheard of, because unattainable, in my boyhood. From the child's toy to the pianoforte in the parlour, the items which make up the home now are better and brighter than those our fathers had. Machinery alone has cheapened them into accessibility.

On Mental and Moral Development.—Mr. Allen Clarke, in his clever little book, "The Effects of the Factory System," draws a pathetic picture of the mental degeneracy of the textile operatives of his native town, Bolton. Allen Clarke is a name highly and deservedly honoured in the labour world, but his reasoning is not always beyond criticism. He attributes the mental deterioration of his towns-

men to the monotony of their occupation, and sighs for the good old time when machines were not. Granted that a life of days of unvaried occupation is dementalising, how would the substitution of hand work for machine work improve matters? The production of thousands of articles or details of articles by hand is surely as monotonous as the production of millions by machine. Hand knitting, hand weaving, hand spinning, offer no more variety than the same operations by machinery. To suggest that machine methods induce mental deterioration is wholly unjustifiable. Repeated operations of any sort are monotonous, but certainly not more so when performed by machine. Rivetting, for instance, is not an occupation which calls for close mental effort, but I can easily believe that a man operating an electrical rivetter has as much interest in his work as though he was closing and snapping his work by sheer muscular effort. I am confident that every repeat operation in the whole industrial world is as interesting now, as ever, to the workers whose lot it is to perform them. Industrial skill and intelligence are just as requisite in a world driven by machinery as in one impelled by manual force. I am certain that I was as interested in my work when a machine planed my timber in a well organised pattern shop as when I had to spend days in "strapping up." Machinery has detracted nothing from labour which gives it interest or stimulates thought on the part of the worker.

The development of highly organised machine systems has induced a sense of order and personal self respect which manual occupation would never bring about. If, in large factories, it has led to a mingling of the sexes, the results are not evil. The unmitigated abominations of the factory system in the early part of the last century have no parallel in our time. The contact of the sexes in our modern system leads more frequently to marriage than to intrigue. The higher the development of the machinery, the better the condition of the factory and the less the dangers of the horrors which provoked the justified denunciations of Sadler, Oastler, and Shaftesbury.

On the Relations of Labour and Capital.—I have previously expressed the belief that, under our present system, the unity of labour and capital is an absurdity and a delusion. It does not exist. The struggle between wage earners and wage payers is as natural as any other struggle in the material world, and will go on in spite of any shifting of venue or alteration of method. But machinery has reduced its virulence and softened its acerbities. The machine has been a better peace maker than either the man or his master. The most effective illustration of this will occur to all who followed and

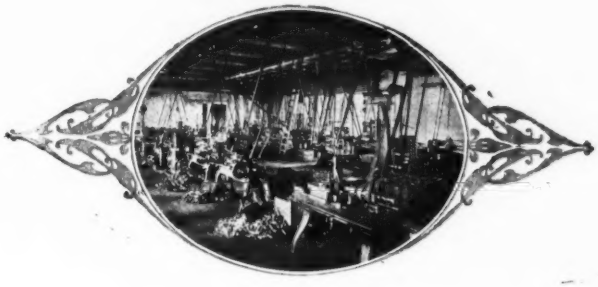
still remember the engineers' lock-out in 1897. One of the terms upon which it closed ostentatiously paraded the fact (never disputed) that "the machine tools are the property of the employer." The employer therefore claimed the sole right of using them as he liked, of appointing whomsoever he pleased to work them, and of paying any wages for the work that seemed good to him. This gratuitous humiliation to the defeated worker was bitterly resented. The smaller spirits on the employer's side laboured it with provocative arrogance. The hot-headed section of the man vehemently denounced it, and but for the restraining influence of their leaders would have made it the *casus belli* of another revolt. Wiser counsels here prevailed on both sides, and though the clause still stands as part of the mutual arrangement between the Amalgamated Society of Engineers and the Employers' Federation, an extreme conception of its meaning and scope is never urged by either side. The machine tools are still the "property" of the employers, but the skill and experience of the worker is also a "property" equally entitled to recognition and consideration. It is true that almost every newly introduced appliance provokes dispute or necessitates the rearrangement of terms and conditions, but with the passing of mutual prejudices the difficulties of adjustment have appreciably diminished.

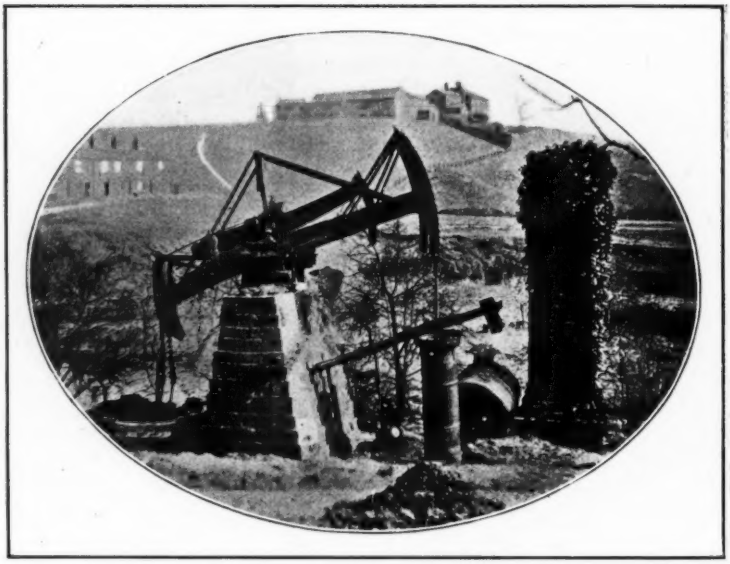
On Physical Degeneracy.—It is no part of my present duty to discuss this terrible phase of modern civilisation in its political or social aspect. To whatever cause our physical deterioration is due, its facts are incontestible. The recruiting statistics in connection with the British army tell a tale that no optimism can explain away. Fifty per cent. of Britain's young manhood in industrial centres is not good enough for her army. It is not merely that the body is shrivelled and the faculties dulled. Incipient consumption, ophthalmia, and other diseases are added to shrunken frames and deformed limbs. Deeply as this race tragedy appeals to me, my only concern with it here is to inquire how far this evil is traceable to machinery. It is a common and plausible theory which attributes this deterioration to the "factory system." As the "factory" era in our industrial history began and has developed with the introduction of machinery, it seems easy to trace the biggest and worst evils to it. The essential fact that is lost sight of is that the horrors of the early years of the "factory" era arose, not from the use, but the misuse of machinery. The callous greed of the old factory lords was uncurbed by any legislative or trade-union restriction and is blameable as the genesis of the workers' physical decay. But to argue by a sequence of propositions that machines

made the factory system, the factory system made the slums, and the slums have produced the physical degenerate, is illogical and untenable. The influence which transformed the stalwart yoemanry of Lancashire into a race of stunted weaklings is assuredly not that of the machine. It is outside the scope of this article to examine such questions as those which arise from a consideration of the most imperative English social questions of our time—the problem of the bad housing of the poor. I am convinced that to bad housing chiefly our physical decadence is due. However, machinery has multiplied, the organised worker has consistently improved in health and longevity. That the improvement arises from better sanitation and a better standard of living is quite true. It still leaves a vast and terrible residuum of our population a long way below the line which divides comparative prosperity from destitution. We have already seen that machinery does not increase poverty by deforcing labour, nor does it accentuate physical deterioration. Wherever its use is the most perfect and efficient, it brings lighter and healthier workshops, better surroundings, sanitation and hygiene. It effaces the perils of many of what are or were known as dangerous occupations. Nobody can visit the Diamond Match Works at Bootle without being struck with the immeasurable superiority of the machine system of producing such simple and essential articles as matches. Machine processes enable us to produce them in millions without the touch of a human hand, and the perils of "phossy jaw" are horrors of the past. No less remarkable is the pneumatic device by which anthrax in the wool-sorting trade is obviated in the best equipped factories in Bradford. In every case the rule prevails that machinery is in itself an unmingled blessing. Its abuse, like the abuse of every other blessing, brings retribution. No man can trace a single glaring wrong or evil to machinery. Physical deterioration, of all others, is the least attributable to machinery. Machinery has brought health to the workshop and comfort to the home. If it has not removed the social anomalies of our time, it has certainly not emphasised them.

Science has not spoken her last word. The machines which fill us with wonder and admiration today will be primitive and ridiculous tomorrow. The duty of the worker, no less than his personal self interest, dictates the whole-hearted and unreluctant acceptance of whatever "labour-saving" devices the inventive faculty of man can produce. The British employer will have to revise his code as well. If the workman is to rise to truer conceptions of labour's duty to the com-

munity by getting the best results from his employer's "property," the employer must offer the incentive. In Great Britain the best worker is ground between the "minimum" of the Society and the "maximum" of the employer. There is no room between them. During the past few days a representative employer has tried to convince me that the whole mischief in the engineering trade is due to the arbitrary and fatuous rule of a "minimum wage." It reduces all men to a dead level and, but for it, I am told that employers would gladly pay according to merit. But the minimum wage is nothing but a limit fixed by the men, below which no man shall work. In this country its highest mark is 40 shillings for 54 hours and in many places it falls below 30 shillings. These figures, which do not take account of a very recent reduction, do not strike one as exorbitant. There is surely room above this to reward special merit, skill, and industry. Special rates of remuneration are rare in Great Britain. The special recognition of special work is an exception, not a rule. That the man should do his best with his machine and the employer his best with his man is an honest and sound principle. Unhappily, it is true that neither party does his best, and, as a result, the machine suffers in proportion, while the country suffers in wealth and reputation. Machinery in any of our great industries has never yet had the effect of devitalising the worker's energy or the employer's enterprise. There are no ruined industries, impaired prospects, or vanished interests to be laid to its account. It is the duty of the worker to get its best results by his own effort. It is the equal duty of the employer to recognise that effort with the highest reward.





NEWCOMEN PUMPING ENGINE, BARDSLEY, NEAR ASHTON-UNDER-LYNE.
OUT OF USE 1830.
From Mr. Henry Davey's paper before the Institution of Mechanical Engineers.

THE PRIME MOVER AND ITS INFLUENCE ON THE WORLD'S PROGRESS.

By John E. Sweet.

While "Production Engineering" is concerned mainly with the economical *application* of power, the basis of the mechanical expansion of the last century is the economical *generation* of power. The prime mover must come before the power-driven tool. We are happy in having this short survey of the rise of steam power, from one who has been a living factor in much of the later and finer development of the steam engine.—THE EDITORS.

MAN can make no material thing without the aid of a tool, an implement, or a machine. In the beginning it is presumable that he made a maul of a stone to crack a nut; it was the embryo hammer, without which man could exist only by living upon roots and herbs and fruit, and civilization could never have been. From the beginning man has been striving and scheming to make things easier and more comfortable for himself. He brought wind and

water and fire to his aid. With his stone hammer he struck fire from the rock; with fire he smelted his ore, and softened his metal out of which he shaped his tools and became the tool-using animal. With his tools he carved out his skiff which the wind wafted over the seas; constructed carts and trained the beasts to carry his burden; built his mill which was turned by falling water, and later when water was scarce the wind turned the mill.

CAPTAIN THOMAS SAVERY. 1650-1715.

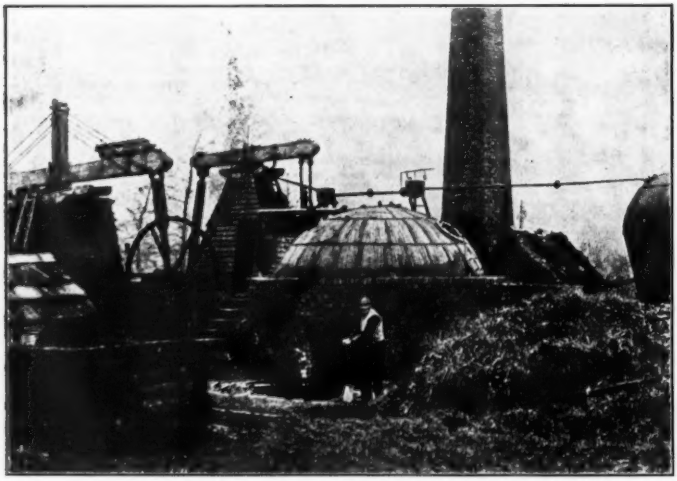
The immediate successor of the Marquess of Worcester in the work of developing the steam engine, and the first to "put in practice the raising of water by fire." The model of his "Miner's Friend" was exhibited before the Royal Society in 1699, the year after his patent was granted.

Man was made to labor, but none of these things was made by labor alone. The material, the tools, the labor, and above all the intelligent guidance of the inventor, were necessary for the production of the least

of these. Man devising things for his comfort devised things for his protection—protection against wild beasts, and protection against the depredation of his neighbors; so his implements of protection became implements of war, and then, as now, the man and the nation that provides for war has war, and the history of the world as it is is the history of wars. The heroes who live in history are the warriors, and the memory of the men who made the things that contributed to the comfort and happiness of mankind, much too soon passed away.

Aside from that carried by the beast of burden and the boats on the rivers and seas, the moving of masses was by the aggregation of human hands. The mills and the ships, the palaces, monuments and prisons were built by the guided multitude. For centuries upon centuries this was kept up. In the Egyptian age, the age of granite, millions of days' labor went into the tombs and temples. Greece with her architecture and sculpture was the work of the hand and chisel. Rome was built by the sweat of the brow, and her paintings made on hand-made cloth; up to the eighteenth century man had only the crudest of tools, scarcely any machinery, and but the wind and the water to second his exertions.

Hero discovered the power of steam, but used it only as a toy, and it was nearly two thousand years before others proposed to put it to



BASSET ATMOSPHERIC ENGINE, DENBY COLLIERY, NEAR DERBY.

Erected in the position shown in 1817, having been in use previously at another pit. Dismounted 1866. From Mr. Henry Davey's paper before the Institution of Mechanical Engineers.

OLIVER EVANS. 1755-1819.

From an engraving by Jackman. By courtesy of Messrs. Wyman & Gordon, Worcester, Mass.

His life is a pathetic record of struggle and poverty, in spite of far-seeing genius and high inventive skill. His millwright inventions revolutionized the milling industry. He was a pioneer in the design of conveying machinery and in steam road locomotion, and the earliest advocate of the high-pressure steam engine.

use. Here and there suggestions and models were made, to die out; and the world went on with hands and tools making what they could, and the nation that had the most tools and the greatest intelligence advanced the most rapidly. Slowly the skiffs grew to boats and the boats to ships, built by hand and controlled by hand. The carts grew to wagons and stages, the roads were made better, animal transportation became general; the water wheel was made larger and more efficient; the wind mill grew from a toy to a machine, and the mills grew

in size, but only by the slow growth of centuries. At the best they relieved only a fraction of the human drudgery; and in what aid man had from nature's powers there was no means of transmitting its energy—the horse and the load, the wind mill and the pump, and the factory and the water wheel went together.

Newcomen advanced farther than others had before him by constructing some working steam engines, but not until the last half of the eighteenth century was much done to meet the wants of an enterprising people. Although use had been made of the then available forces, after the advent of the steam engine they were made more available. The mind of man had reached its limit centuries before in mathematics, literature, philosophy, and poetry; sculpture and painting had been brought to as high a pitch as now, and undeveloped invention had shown flashes of light; but not until the work of James Watt gave new life to industries and pushed ahead the century of invention had there been any such advance towards relieving human efforts as followed.

Matthew Boulton, the partner of Watt, in conversation with King George III, was asked "In what business are you engaged?" and he replied, "I am engaged, your Majesty, in the production of a commodity which is the desire of Kings." "And what is that? What is that?" asked the King. *"Power,* your Majesty," replied Boulton; he might have said "I have what all the world wants, and I have what will do more to help relieve the laborers of the world, and I have what will do more to advance civilization, than ever has been done, and more than will be done in all other ways for the next two hundred years."

What material thing is there in sight, what human achievement, what is there worth having that has not behind it, or connected with it in some way—the steam engine?

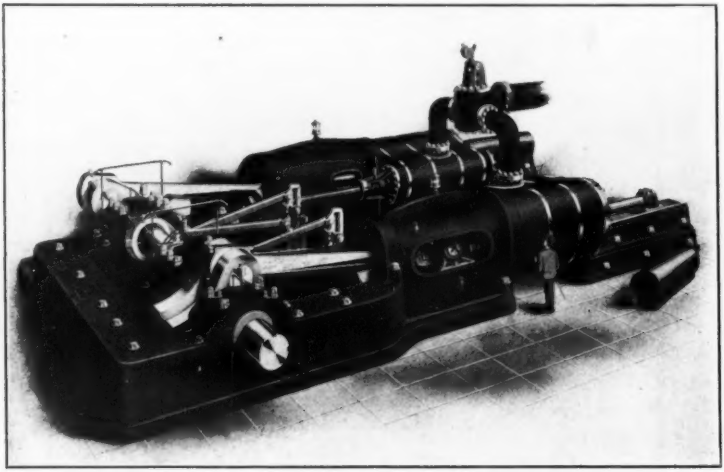
When the marvels of the steam engine are mentioned, we instinctively associate it with the great ocean steamers with their 10,000, 15,000, 30,000 horse power; with the great electric power stations, the rolling mills, and blast furnaces; but there is not a thread in the clothing we wear that has not been carded and twisted and spun and transported by the power of steam; not a spool, a needle, or a pin but, many times over, the steam engine has been prime mover in the various operations of its production. Steam has so outgrown other natural powers and gone so marvelously beyond all other artificial powers as to be the one thing that has revolutionized all forms of human endeavor. But a century ago the aid given to human labor by nature's forces was a small part of the whole; now human effort supplies but a trivial fraction of the energy employed for useful purposes.

MATTHEW BOULTON. 1728-1809.

The partner of Watt, by the acquisition of the interest in Watt's patent formerly owned by Roebuck. Much of the practical success attained by Watt's inventions was due to the intelligent, broad-minded, but discriminating support afforded by Boulton's business ability and financial backing.

Fields are plowed and cultivated, crops planted and harvested, grains transported and ground, and flour kneaded by gĕnerated power. Timber is cut and sawed to dimensions, planed and framed, shaped and moulded and sand-papered; house-joinery and furniture is made by machinery; the crockery, the glass, the silver-plate, cutlery, toilet articles, bric-a-brac, and matches—all have the steam engine back of them. Building stone is quarried, transported, sawed or planed, and carried to its place in the building. Monuments are cut and polished, statues carved, bricks made, carried, and hoisted to their place; mortar is mixed, wood-work painted, builders' hardware made; iron ore is dug, lifted by steam cranes, conveyed to the top of the blast furnaces,

smelted and pigged or blown into steel, cast or rolled into blooms, billets, beams and bars, sawed to lengths, cut and shaped and punched, bent and riveted; worked into ships, buildings, bridges, and boilers, engines, machines, bolts, rivets, wire, nails and brads—and all by the aid of the steam engine. By steam, harbors have been dredged, canals



THREE-BEARING REVERSING ROLLING-MILL ENGINE.

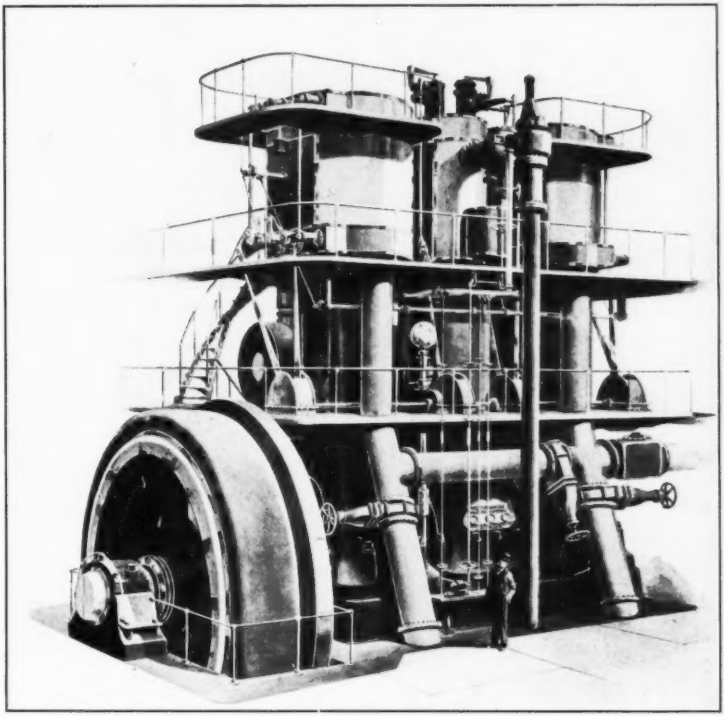
A product of the demand of the modern steel industry upon steam power. 54-inch cylinders, 66-inch stroke; weight of one bed casting, 86 tons; built for Lackawanna Steel Co. by the William Tod Co., Youngstown, Ohio.

dug, tunnels made, docks built, steamships made to traverse every water on the globe, railroads to traverse every country. One may go to the Pyramids, up the Nile, to the pinnacle of a dozen mountains. Railroads traverse our plains, cross and re-cross India; one may ride in Africa and Alaska, go from Spain to Siberia, from Maine to Mexico; diamonds are mined in Kimberley and gold washed out in Alaska; jewels are cut and money coined; paper, ink and books made—in fact, not only every material thing we see and use, but the immaterial—electricity, light, power, and even heat—are made by steam power. The electric telegraph is worked, our houses and cities lighted and the map of the country is cob-webbed by lines of street-car roads where the steam engine is the prime mover; and all these wonderful changes have been wrought in five quarters of a century.

The steam boat has grown from the Clermont to the Celtic in a century; the locomotive from the Rocket to the mountain climbers, in

three-quarters of a century, and the street-car lines in a quarter. I have seen both a Newcomen and a Watt engine running, and there is one of the latter still running in Birmingham; I have seen the railroads, telegraph, electric lights and electric railroads come into existence, and then wonder what can steam do more. No! not what can it do, but what can it not do? If the steam engines of today were hitched to a star and set to pulling back on the earth, our days and years would be lengthened and perhaps the harmony of the universe upset.

How futile it would be to attempt to do by manual labor the work performed by the steam engine! An ocean steamer of the Lucania class is propelled by a force of 30,000 horse power; counting 6 men to



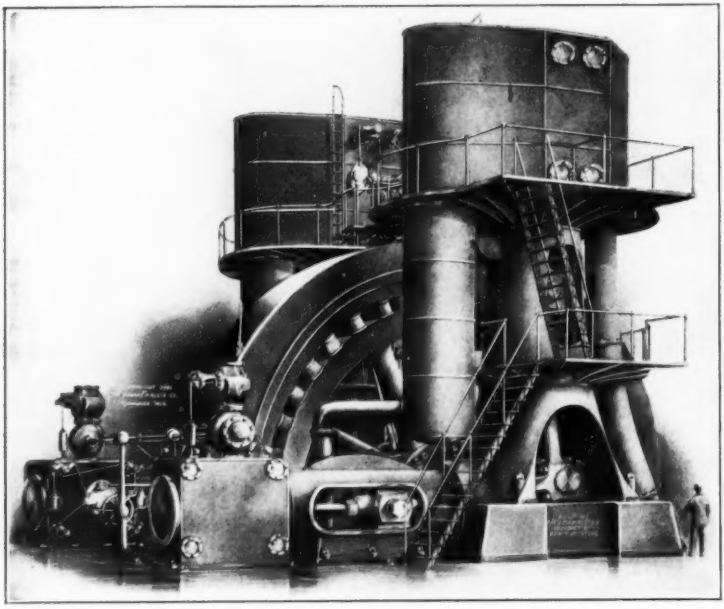
WESTINGHOUSE THREE-CYLINDER COMPOUND STEAM ENGINE, NEW YORK EDISON CO.

One of eleven units in station. Poppet valves on high-pressure and Corliss valves on low-pressure cylinders; cylinders 43½, 75½, and 75½ inches, stroke 60 inches; 75 revolutions; 7,500 maximum horse power. Floor space 40 by 29 feet, height 34 feet.
Westinghouse Machine Co.

the horse power and three shifts every 24 hours, the mere driving of the ship would call for 540,000 men; and if such a vessel could carry 10,000 men and their provisions it would be only 1/54 of the size necessary to carry its own motive power. Without steam our present ocean service could not be, nor could one of our passenger trains carry a sufficient number of human laborers to propel itself at present speeds and continued service, to say nothing of the freight; and the same computation will show that the entire working force of New York City could not do the work of the one single 80,000-horse-power plant recently built to supply the elevated railroads of the city.

The heat engine, steam, and its offspring—gas—are doing three-fourths of the world's work; and where the heat engine is the most used there is where the world is best civilized and where idleness, suffering, and poverty are the least common.

For fifty years the best engineering talent of the world has devoted itself to reducing the waste of fuel in generating steam, to accomplish-



REYNOLDS COMBINED VERTICAL AND HORIZONTAL ENGINE.

Built by the Edward P. Allis Co. (now the Allis-Chalmers Co.). Designed to operate at 8,000 horse power as the most efficient load, and capable of a continuous output of 12,000 horse power. Type designed for the elevated railroads of New York City.

ing the more economical use of the steam in the steam engine, and to developing a better use of the fuel by converting it into gas and using it in the gas engine. So successful has it been that probably five times the work is done with the same amount of coal that was done fifty years ago; and yet twenty-five years ago, when nearly twice as much coal as now was used for the same work, the best engineers thought they were near the limit. In view of the continual advances, he would be a bold man who would say we have come to the end!

At the appalling rate we are now exhausting our coal supply, it would seem as if that would stop the steam engine; but as it has been shown that the otherwise unavailable land of the world will raise one hundred times as much fuel a year as we now consume in a year, there would appear to be no end of the heat engine, unless the available energy in the coal can be converted into electric energy—a thing some of the scientists consider doable in some untried way.

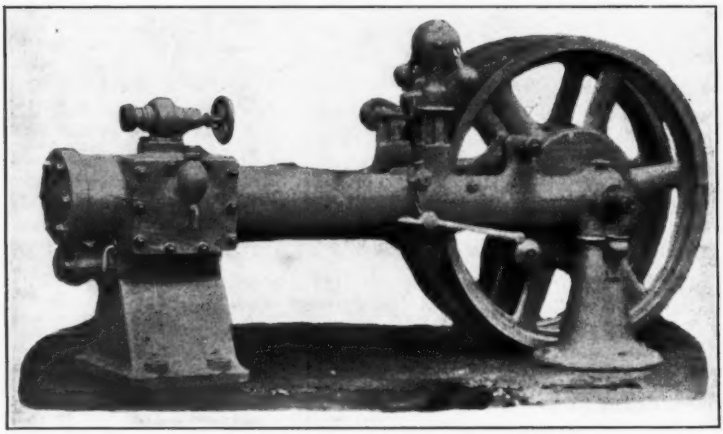
Different countries of seeming equal natural advantages vary greatly in their material prosperity, as is the case with Europe and Asia and North and South America; while the lack of the use of the steam engine may not be the cause of it, it is certain that the most backward could not have kept pace with the prosperous without availing themselves of the advantages of the artificial power.

The Doing.

In the beginning, boilers were made to carry only from 7 to 15 pounds, and in 1850 50 pounds was common practice. The pressure in marine boilers on ocean steamers was much less, and locomotives and river steamers seldom reached over 100 pounds. In 1880, return-tubular boilers seldom carried over 80 pounds, and engines were rated on that pressure. The water-tube boiler had just begun to make its way, and this opened up the field for higher pressures, leading to improvements in the return-tubular boiler, and to the development of others forms, until now it is common to find return-tubular boilers of 150 horse power running as high as 150-pounds pressure, and water-tube and internally fired boilers of the marine sort up to any pressure under which ordinary engines will run.

Flash boilers have been experimented with for many years—in the main, with common failure; they may do for torpedo boats and automobiles, but unless some way can be found to prolong their lives they will meet special cases only. As the case stands today, judging from numbers, the fire-tube, locomotive, the return-tubular horizontal, and the water-tube of the Babcock & Wilcox sort are the types in general use. The vertical boiler has fought a losing battle on the whole.

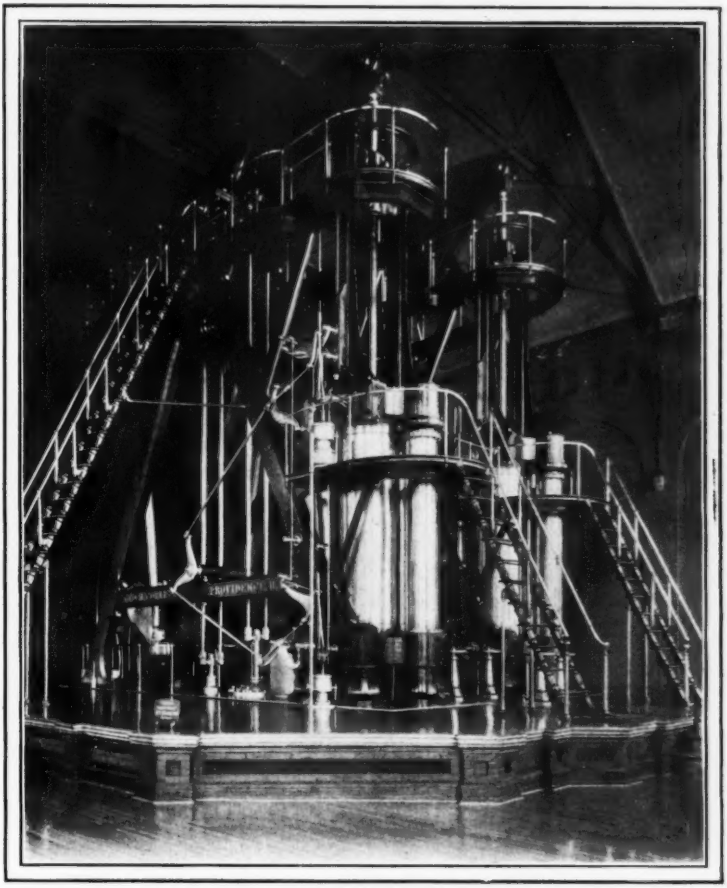
Furnaces and firebars or grates have received any amount of thought and experiment, and automatic stokers have been made of many kinds, with some advance in economy and a greater one in black-smoke prevention. Many of the most promising schemes fail because of its costing too much to make them work. One economical device which saved $15 a day in labor cost $40 a day for steam to run it, besides a good deal for maintenance, and like many another economical device, it cost too much.



THE STRAIGHT-LINE ENGINE OF 1871-1872.

Altogether through the furnaces there has been considerable gain over early practice, and this has been by the use of better materials, better workmanship, and better designs—and more than all, by making it possible to use higher pressure. An enormous amount of heat has to go into water before it is converted into steam, and no practical way has as yet been devised by which this heat can be converted directly into work. After the water is converted into steam, then the more heat there is put into it the greater the percent. of the entire heat is available for work. It is the common remark that the steam engine is a wasteful machine, but why the unavailable heat that is put into the water by the boiler and the other boiler losses are charged to the engine is not apparent.

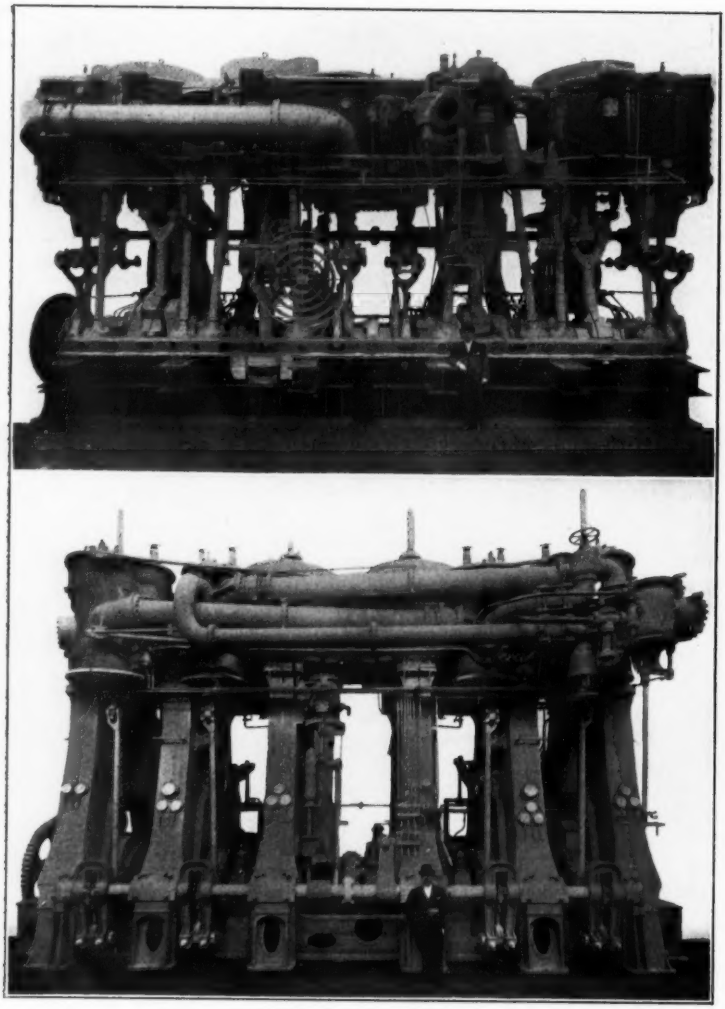
The steam engines of Newcomen and Watt originated out of the requirements for pumping; using a beam was exactly the thing to do, and it was not an unnatural; nor, in fact, a very bad thing to use when transmitting the reciprocating motion to a crank and converting it



THE HISTORICAL CORLISS ENGINE OF THE CENTENNIAL EXHIBITION, PHILADELPHIA, 1876.

Now working in the shops of the Pullman Co., Pullman, Ill. This engine drove all the shafting in "Machinery Hall," and was the most prominent exhibit in the building, but *hors concours*. It consisted of a pair of beam engines working expansively at 80 pounds; cylinders 40 inches, stroke 10 feet; beams 27 feet long, 9 feet deep; flywheel 30 feet diameter, 2 feet face, weight 56 tons—probably the largest cut-gear wheel ever made. 36 revolutions, 1,400 horse power with a maximum of 2,000. The illustration is presented by the courtesy of the Allis-Chalmers Company.

into rotative motion under the conditions existing at that time. The beam engine held its own for years after the crosshead plan came into use; in fact, it has hardly gone out of favor yet. Mr. Corliss used the

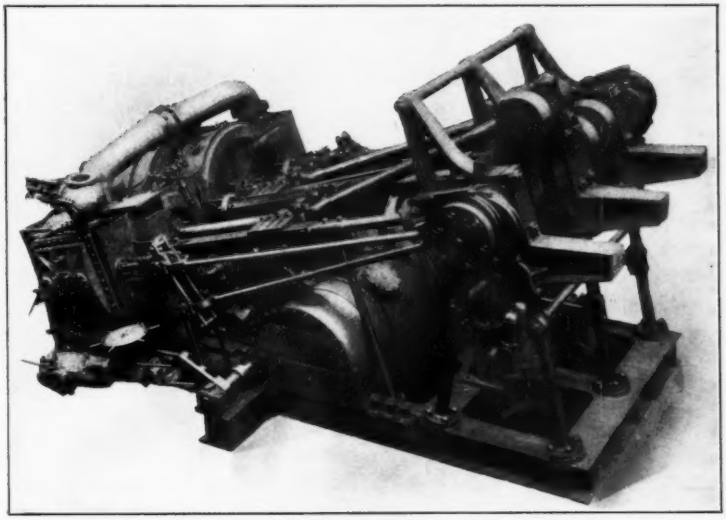


MODERN MARINE ENGINE TYPES.

The upper picture shows the engines of H. M. S. Lancaster, the lower one the engines of the Russian volunteer fleet twin-screw steamer Smolensk; both built by R. & W. Hawthorne, Leslie & Co., St. Peter's Works, Newcastle-on-Tyne.

type in his monumental engine at the Centennial Exhibition in 1876, and as Mr. Porter pointed out at the time, the beam acts as a reciprocating flywheel to absorb the excessive pressure and relieve the crank pin at the beginning of the stroke, and increase it at the last end as the pressure falls off. In ocean and in some river steamers, side beams were used—that is, instead of the beams being placed on gallows frames over the cylinder and crank, two beams were by the side of the cylinder in the bottom of the ship, return connecting rods coming down from a crosshead.

The Watt parallel motion which took the place of crosshead and guide was a brilliant invention. It was ingenious and effective, and enabled the builders of the period to do the work when they had no facilities for making the crossheads and guides cheaply.



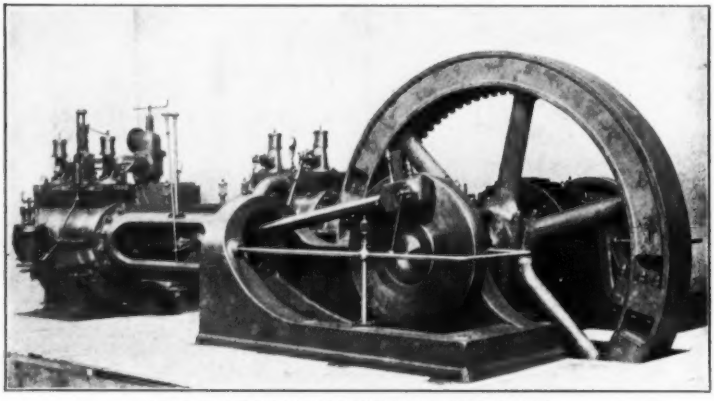
A MARINE TYPE. ENGINES OF THE PADDLE STEAMER DUCHESS OF KENT.
Built by Day, Summers & Co., Ltd., Southampton.

The introduction of steam propulsion into war vessels drove out the beam engine and led to various designs, both successful and the reverse. Horizontal athwart ship engines, with trunk pistons, oscillating cylinders, return connecting rods, and various compact constructions have given way to the direct-connected upright type, with compound, triple, and quadruple cylinders; and in this connection it may be appropriate to refer to the reluctance with which some of the best en-

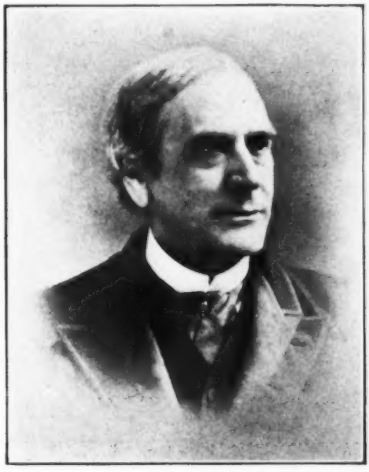
gineers accepted the fact that there was economy in the compound system.

In the land service engine there has been a much wider range of modifications and freaks than in the marine service, Who was first to depart from the beam engine to the horizontal square-bed engine, it would likely be difficult to find out, but it must have been a standard for many years, both before Mr. Corliss grasped the subject and threw away the useless half, putting the metal in the line of strain, and for many years thereafter. It would be as difficult too to tell when men began to build rotary engines. To say that there have been a thousand different forms of the sort where the steam is made to push a piston around in a circle and turn the shaft direct would no doubt be far within the limit, and if there has been a uniformity in any one thing it has been the uniform failure of all attempts in this line and the loss of the thousands of dollars has been caused by a misconception of the conditions—first in the idea that there was a great loss in the use of a crank and that the dead centre was a very objectionable feature, and second in the lack of understanding that the losses in the steam engine are heat and friction losses, in which the rotary of that form, even if mechanically good, would kill it. The only rotary engines of any form that have been at all successful have been of the turbine sort, and up to the appearance of the DeLaval and Parsons turbines, the Avery engine, which was also a turbine, had been the only one that ever reached a commercial standing.

About the middle of the nineteenth century, Sickles and Corliss



COUPLED COMPOUND HORIZONTAL FIXED ENGINE.
Robey & Co., Ltd., Lincoln, England.



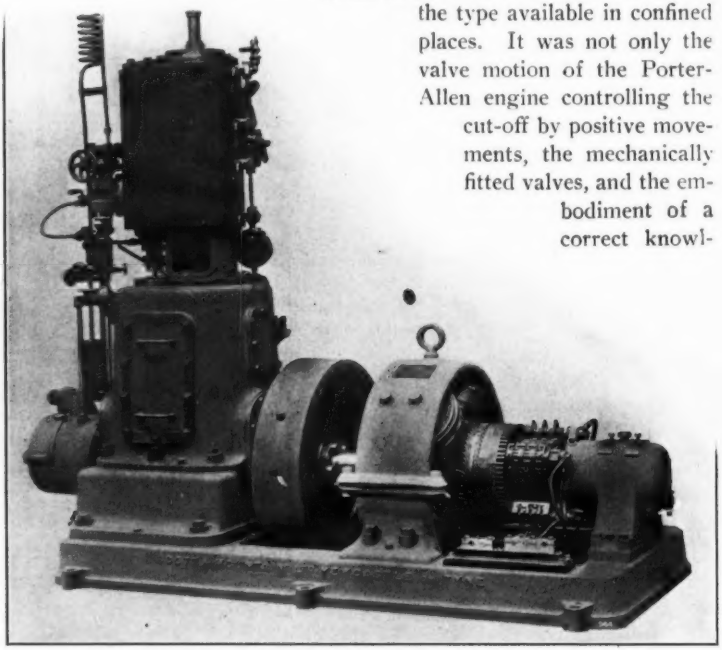
GEORGE H. CORLISS. 1817-1888.

Inventor of the automatic cut-off gear for steam engines, and the practical developer of the four-valve automatic engine.

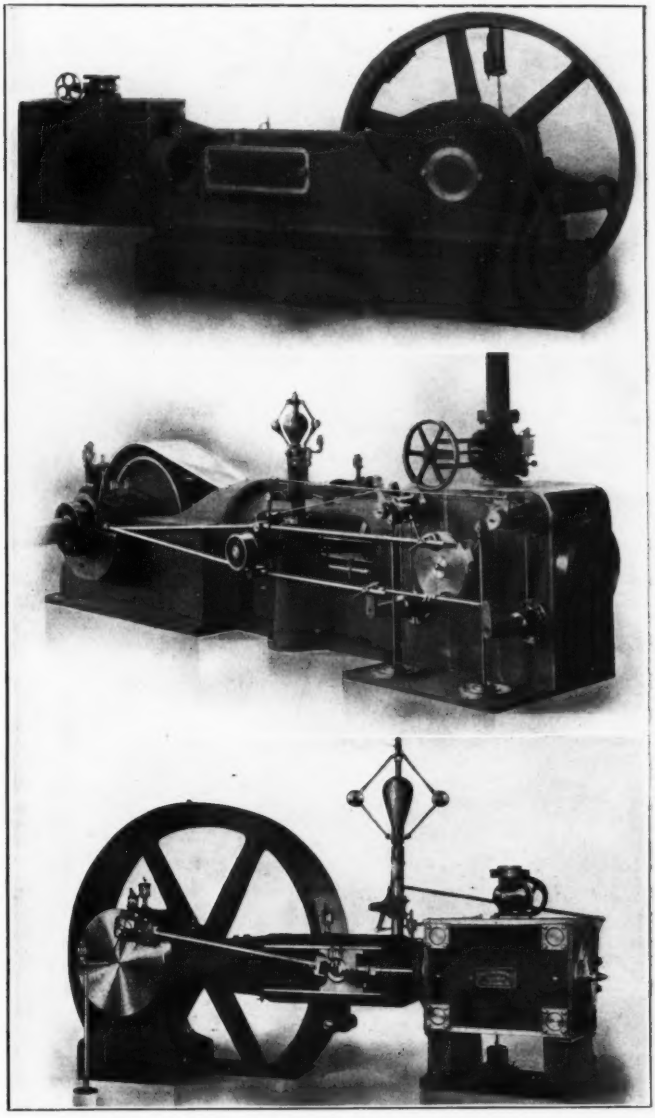
marked the beginning of a new period in steam-engine work. They not only showed the advantage of a drop cut-off, but Mr. Corliss "builded better than he knew." His governor-controlled cut-off, the four easy moving valves, the liberal exhaust ports which dropped out the steam and the water of condensation as well, really constituted the design of a new engine, and what there was of it was right for the time and conditions; the pedestal under the main bearing was the main support as it needed to be, and it was rigid in the right direction to resist the momentum of the reciprocating parts. The pedestals under the cylinder were located crosswise, permitting expansion of the frame and resisting the side swing of the cylinder whose whole tendency was to swing from side to side. These things were right and the en-

gine so far self-contained. When steam pressures were raised and the frames proved too weak, builders chose to spend their money in other ways than the simple one of making the frame stronger. When we realize that the Corliss engine which in 1867 in Paris met with both approval and ridicule from the engineers, made its way the world over, its marvelous worth becomes apparent.

Allen and Porter designed the true high-speed engine twenty years before extensive use demanded it. It was the beginning of another era in steam-engine construction and the twenty-year period of waiting was not lost, as it proved that the high-speed engine could be made successful and durable. While the electric-light people claim that the electric-light business built up the high-speed engine, it is certain that the electric-light business would never have gone forward with its whirlwind prosperity, if it had not been for the single valve, centre crank, shaft governed high-speed engine. With it good governing under widely varying loads was made possible, and great power in a small space rendered the type available in confined places. It was not only the valve motion of the Porter-Allen engine controlling the cut-off by positive movements, the mechanically fitted valves, and the embodiment of a correct knowl-

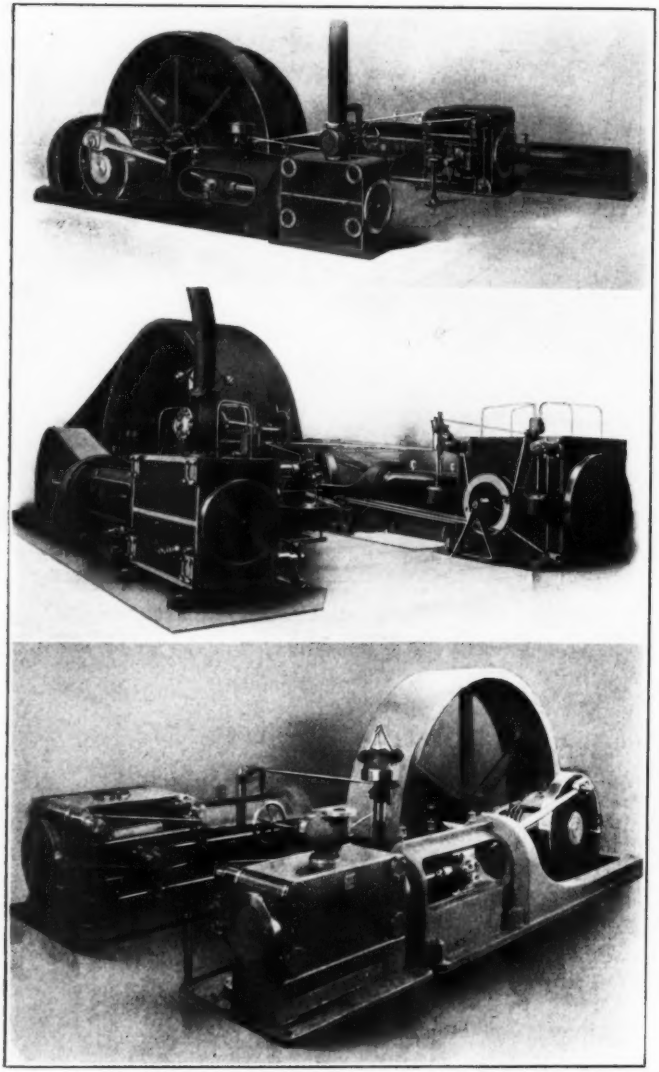


SMALL TANDEM COMBINED ENCLOSED ENGINE AND DYNAMO.



MODERN SIMPLE CORLISS ENGINES AND ALLIED TYPES.

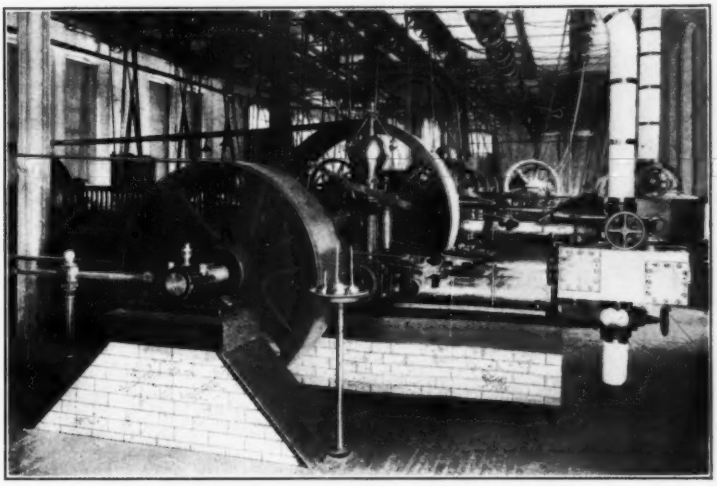
At the top is the 20 by 24 "shaft-governor Corliss" of the Ball Engine Co., Erie, Pa. In the middle is a simple Corliss by the Atlas Engine Works, Indianapolis. At the bottom is a girder-frame Corliss by the Pennsylvania Iron Works.



MODERN TYPES OF COMPOUND CORLISS ENGINES.

At the top is a cross-compound by the William Tod Co., Youngstown, Ohio; the middle one is by the Hooven, Owens, Rentschler Co., Hamilton, Ohio; the lowest is a 350-horse-power engine, 14 and 26 by 42 inches, by the Brown Corliss Engine Co., Corliss, Wis.

edge of the effect of inertia and momentum which made this engine notable. Mr. Porter had designed an engine which was a type that has been extensively followed.



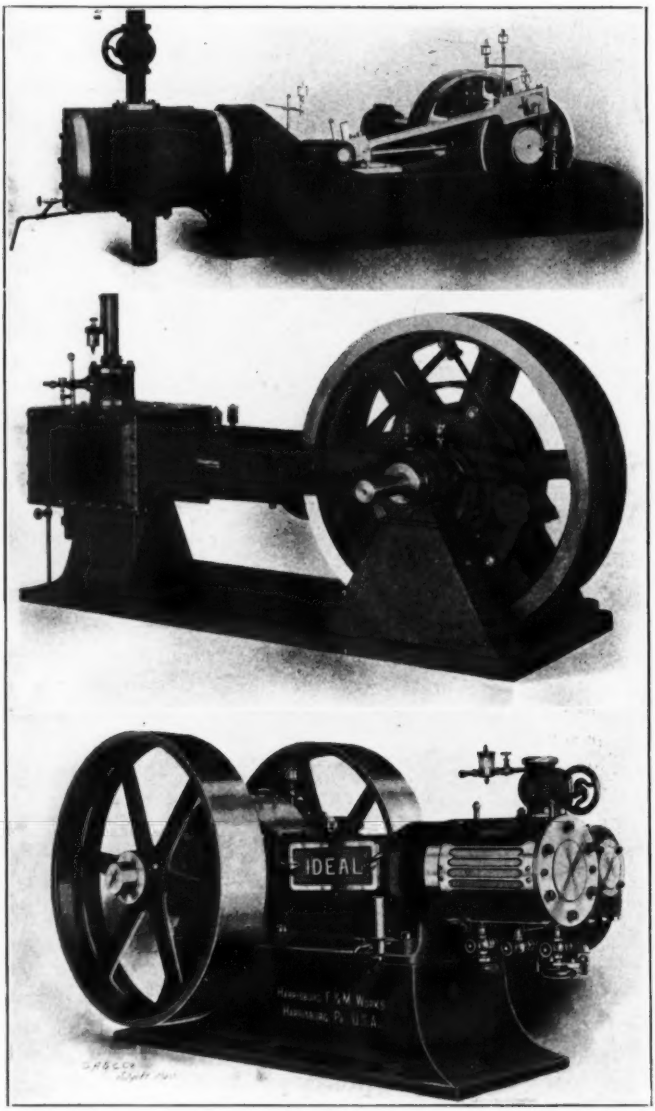
THE MODERN FORM OF THE PORTER-ALLEN ENGINE.

Southwark Foundry & Machine Co., Philadelphia.

Although the gas engine came into notice about the same time the high-speed engine did, and notwithstanding its advantage in fuel economy and in many other ways, it has lagged behind it in coming into general use. The gas engine has grown from the 3 or 4-horse-power ones of the explosive sort, which shot a heavy piston up in the air to turn a shaft as it fell, to monstrous machines working on blast-furnace gas.

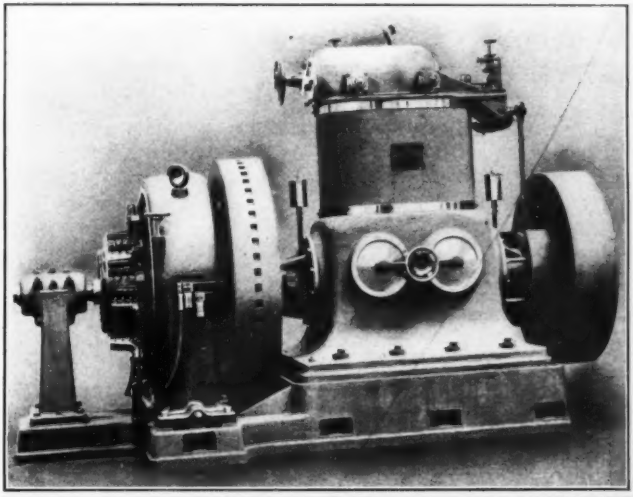
The single-acting enclosed type of the Westinghouse and Willans class followed the high speed in time, and exceeded it in speed; and now the turbine engine of higher speed still, twenty years later, follows these. The vertical marine type, compound and triple-expansion, have come into service for pumping; and in the monstrous modern power stations, and in order to get more cylinders to act upon one shaft, the horizontal and vertical have been combined.

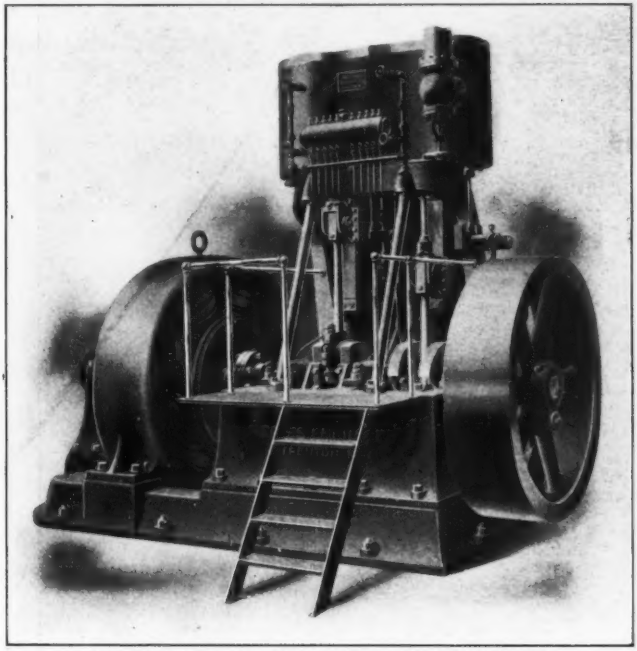
The main strife has been for economy in coal consumption, but the fact that thousands of uneconomical engines have been and are being sold shows that the coal bill has not been all that has been thought of. For electric-light purposes, constant service, good gov-



MODERN AMERICAN HIGH-SPEED AUTOMATIC ENGINES.

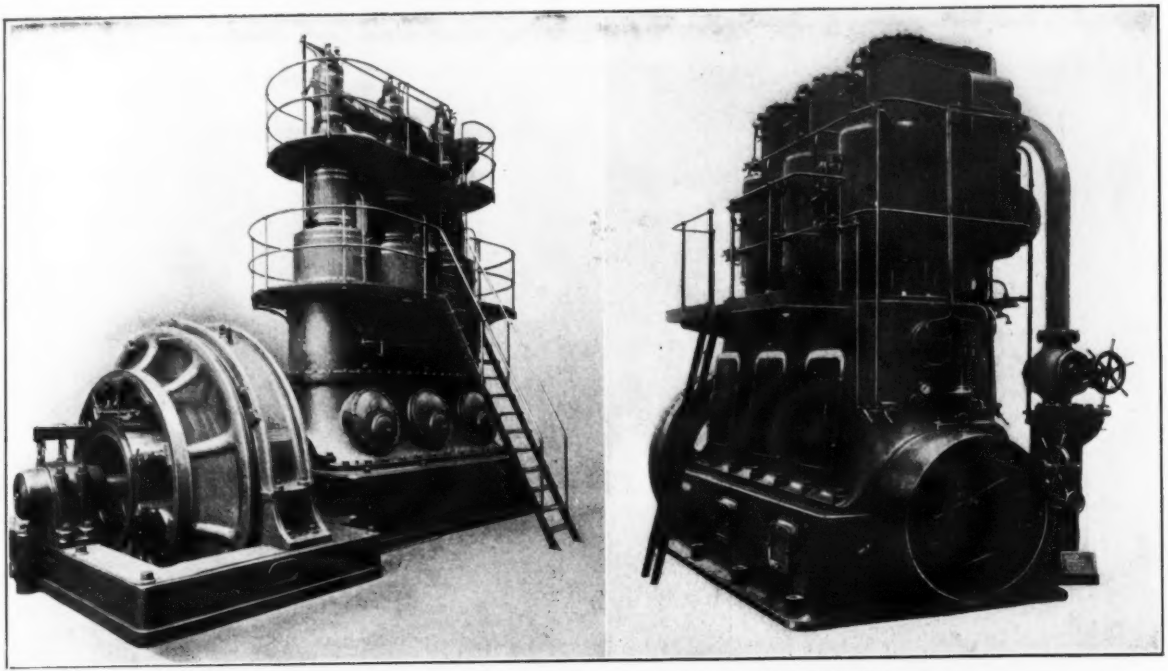
At the top is the Atlas "standard heavy-duty side-crank." In the middle is the Straight Line engine. At the bottom is the Harrisburg Foundry & Machine Works Ideal.





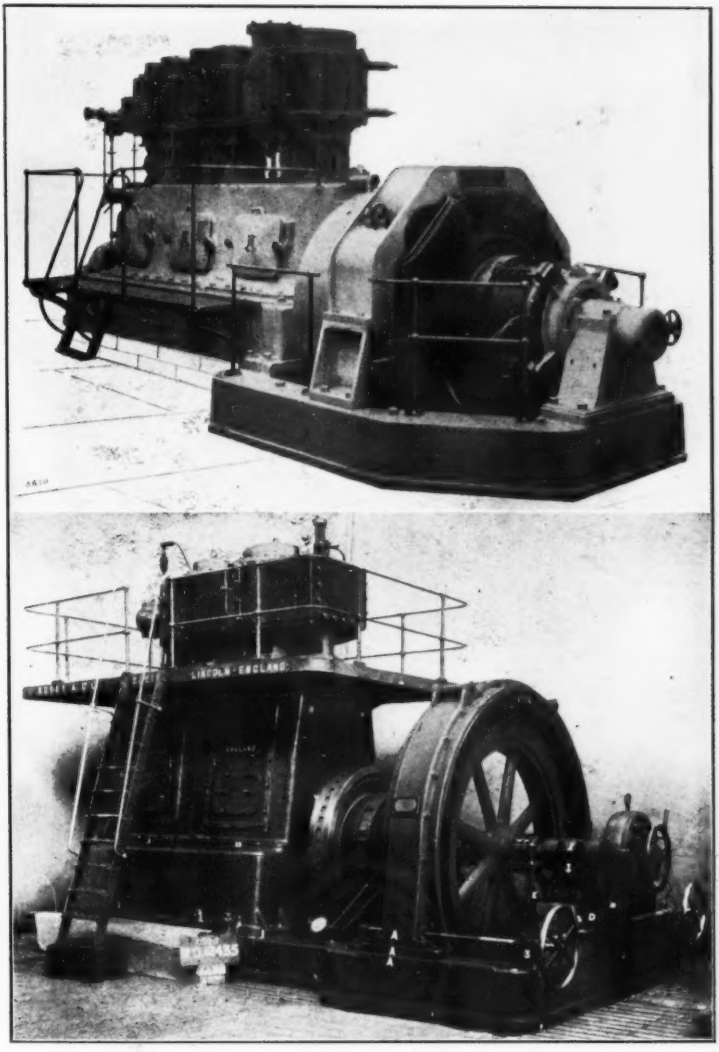
AMERICAN ENCLOSED HIGH-SPEED COMPOUND ENGINES.

Above is a Westinghouse engine of 250 horse power; cylinders 14 and 24 by 14, 280 revolutions; floor space 14½ by 7 feet; height 9½ feet. Below is a Reeves 330-horse-power engine, cylinders 15 and 26 by 18, 200 revolutions. Floor space 190 by 106 inches. It is shown with the casing removed.



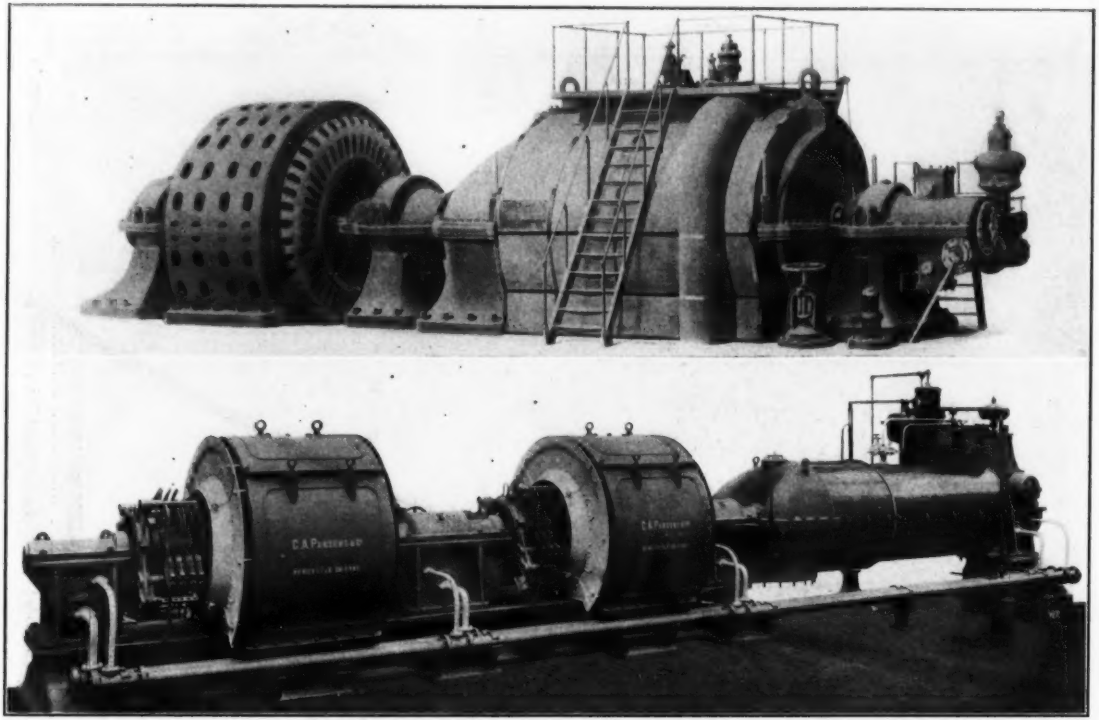
MODERN TYPES OF BRITISH HIGH-SPEED ENCLOSED STEAM ENGINES.

On the left is a Willans nine-cylinder triple-expansion engine—one of the units in Pumpfields Station, Liverpool; cylinders 15, 20½, and 34⅝ inches; stroke 18⅞ inches; drives a Siemens dynamo of 1,420 amperes at 550 volts. On the right is a Browett & Lindley high-speed 1,500-horse-power engine for the Liverpool Overhead Railway.



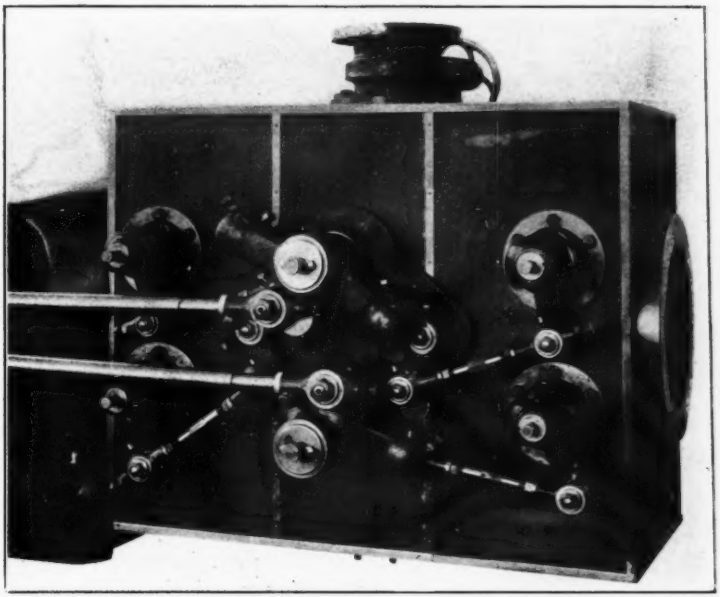
BRITISH HIGH-SPEED ENCLOSED ENGINES.

The upper figure is a three-crank triple-expansion 400-horse-power engine, 360 revolutions, by Alley & MacLellan, Ltd., Glasgow. The lower is a compound for electric lighting, by Robey & Co., Ltd., Lincoln.



THE LOWER FIGURE SHOWS THE PARSONS STEAM TURBINE—THE UPPER ONE THE WESTINGHOUSE-PARSONS TYPE.

The Westinghouse-Parsons turbine shown is a 7,300-horse-power (5,500-kilowatt) machine for the P., N. Y. & L. I. R. R.—750 revolutions, 175-pounds pressure. It is 47 feet long, 14¾ wide, 14 high. The Parsons turbo-dynamo is of 1,000-kilowatts capacity, built by C. A. Parsons & Co. for the Newcastle and District Electric Lighting Co., Ltd. It is of condensing type, and takes steam at 180-pounds pressure.



THE ARMSTRONG-CORLISS VALVE GEAR.

Operated by a shaft governor, giving a positive motion to the valves practically identical with that given by the Corliss detaching valve gear. Ball Engine Co., Erie, Pa.

erning, quiet running in isolated plants where exhaust steam is used for heating—all are of more importance than steam economy.

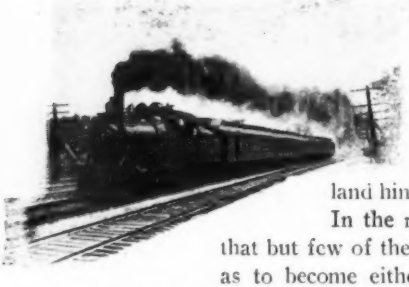
In mills and large power stations any amount of expense seems to be justified if the coal consumption can be reduced, and to accomplish this, higher steam pressure, superheating, more correctly operated valves, reduced clearance, multiple cylinders, the condenser, better workmanship and more perfect lubrication, have all contributed to reach results. At present the trend of improvements is in the direction of direct-connected Corliss valves (that duplicate the effect of the drop cut-off without the detaching element, so as to permit of higher speed); the greater use of the gas engine suited to natural, producer, and blast-furnace gases; and the turbine engine of the DeLaval, Parsons, or Curtis class.

Who could form an estimate of the amount of work that has been expended to bring about present results, and who can comprehend the wasted genius, blasted hopes, and money lost by failures?

WHAT THE INVENTOR HAS DONE FOR THE RAILWAY WORKER.

By Arthur M. Waitt.

There are few manifestations of the use of mechanical power more impressive than the railway, and perhaps none that have had a greater direct influence on industrial civilization and the conditions of life. It is a type and an epitome of the effect of labor-saving machinery. And like the authors whose articles have preceded, Mr. Waitt has taken an intimate part in the development of which he writes. His life has found active expression in the upbuilding of the motive power of a great railway. His review has therefore the vitality of a personal record.—THE EDITORS.



IN the popular mind in the year 1904, the inventor is most frequently thought of as one who is devising "new and useful improvements," simply with the object of obtaining a patent which may land him on the road to fame and fortune. In the railroad field, at least, it is a fact that but few of the inventors have been so fortunate as to become either rich or famous through their inventions, and most of the many improvements have come into use free from any patent-office entanglements. A few notable exceptions, however, exist, and two or three of the most helpful inventions for the improvement of the railroad service have brought not only reputation, but fortune to their originators.

Unfortunately there exists too large a class of individuals who have to live by their wits (not their wisdom)—who spend much of their time in devising new and wonderfully made contrivances, about which they know little, either in theory or in practice—and these unfortunate men, who are a prey to unprincipled patent lawyers, are the ones who by the superficial mind are first thought of as representatives of the *genus homo* known as inventors.

Popularly speaking, the hope of getting a money-making patent is the incentive to invention. Actually, "*necessity* is the mother of invention," and it is such necessities that have given us the sewing machine, the printing press, the Pullman car, and the modern locomotive.

Perhaps no better idea of the work, both mercenary and philanthropic, done by the inventor for railroad men, can be obtained than by a view of the railroads and the railroad equipment as they existed in their infancy nearly seventy-five years ago, and by following their progress, through the indefatigable work of the inventor, up to the modern development in the wonderful service and equipment of the railways of today.

The then marvelous railway of the early nineteenth century was equipped with a track composed of strap or thin bar iron, about one and three-quarters inches wide, rolled in lengths of 15 feet and weighing about 20 pounds to the yard, supported on longitudinal stringers. The Stephenson locomotive, the "Rocket," weighed 4½ tons. The boiler contained twenty-five 3-inch copper tubes, and was 6 feet long and 40 inches in diameter. The cylinders were inclined and coupled to a single pair of driving wheels. This engine could draw a single carriage at 25 to 30 miles per hour. The carriages were simply duplicates of an old stage-coach body set up on a simple framework which was carried by two pairs of wheels. The signal code was very primitive. When a train was to be stopped at a station or a house at night, a common candle was lighted and placed in the window. On the road, when it was desired to stop a train, a piece of tow line was ignited by a shovelful of red-hot coals. Brakes of the ordinary kind used on stage coaches were all that were provided.

From this crude beginning, the inventor, often with little or no recompense except his own consciousness of the benefits he was conferring, has developed our modern railroad, the marvel of the past century. It might be interesting to trace the work of the inventor in developing the modern track with its cross ties of wood or pressed steel, its heavy T rail weighing 100 pounds to the yard, the money-saving tie plates, the splice bars, the safety switches, and the elastic frogs; it might also be profitable to trace the growth of the locomotive from the diminutive "Rocket" to the modern Atlantic or Pacific types of passenger engines, or the consolidation or decapod freight locomotives; and also to trace the car from the old stage-coach type to the modern coach, or the Pullman sleeper and the dining car with their many home comforts. Much of this interesting development of the inventor would not however pertain to the especial benefit of the railroad worker.

Most prominent among the inventions especially helpful to the railway man, as well as to the general public, are the automatic coupler, the automatic quick-action air brake, the steam heating of cars, the application of gas or electricity for car lighting, the pneumatic and other styles of interlocking switches, the block signal systems, the use of telegraphic train orders, and the modern methods of handling coal.

In the workshops of the railroad, the workers have been benefited by the many great improvements which have especially made the life and condition of the American mechanic far superior to his European brothers in labor. Hydraulic and electric cranes for handling heavy work, electric lighting for shops, improved systems of shop heating and ventilation, pneumatic tools as a substitute for the slower and more laborious hand tools, have all made it possible for the shop worker to earn more money, enjoy more rest, have better shop and home surroundings, and find more employment than ever before in the history of the world.

It will be of interest to consider more at length the results to the worker of some of the more marked developments of our inventors in the railroad field. Probably no two inventions have done more to benefit the railway men in actual train service than the automatic coupler, and the automatic quick-action air brake.

The automatic coupler is primarily a device to improve the conditions surrounding the life of switchmen and trainmen, first brought out by Ezra Miller of Dunkirk, N. Y., in 1863, in connection with a platform construction for the added safety to passengers. It brought about, by its universal adoption in the United States, the doing away with the necessity for employees going in between the cars in order to couple or to uncouple them. The fact that dangers were still found, even with the Miller coupler, led to an improvement made by Janney some years later, which became the basis of the Master Car Builders' "standard coupler," which is the universally adopted safety coupler in use all over the United States, for both freight and passenger cars and for locomotives. The benefit of this invention is most clearly shown by referring to the remarks of Mr. E. A. Moseley, Secretary of the Interstate Commerce Commission, before the Master Car Builders' Association at their annual convention in June, 1903, from which I quote:—

> "It must be very gratifying to you to know that the report for the year 1902 shows that the annual number of casualties due to coupling and uncoupling has, since the law was enacted in 1893, been diminished more than nine thousand; the number of employees killed, shows a diminution

of sixty-eight per cent., and the number injured, of eighty-one per cent.; and this notwithstanding the fact that there were from fifteen to twenty thousand more men engaged in coupling cars on the later date."

It is oftentimes the erroneous conclusion in connection with automatic devices, that, as they supersede the necessity for so much manual labor, the result is to throw out of employment many workers. Not so with the automatic coupler. Not only has it saved thousands of lives and limbs, but it has enabled the railroads to handle more business in less time, and for less money, and also to handle heavier trains with safety, thereby taking care of more traffic on a given piece of railway. This has made work for more men in every department. The work of the trainman, and especially that of the switchman, has been rendered less hazardous; trains are made up with greater rapidity; trainmen lose less time on the road from breakage of couplers, and the breaking apart of trains due to such breakage of couplers.

Of equal importance and benefit to the railroad man was the invention of the simple air brake, and afterwards of the quick-action automatic air brake by George Westinghouse. Without doubt this invention has been more far-reaching in its results than any other invention connected with railroad equipment.

The primitive stage-coach brake of 1830 gave way some twenty years later to the Hodge and the Stevens type, operated by a wheel and a shaft located at the end of the cars. Later came the Tanner and the Creamer brakes, each being an improvement over the previous types in safety, ease of application, and effectiveness.

In 1869 George Westinghouse brought out his first successful air brake, with which the engineman could control the train by means of air pressure generated by a pump located on the locomotive, and conducted back through the train, by means of pipes having flexible connections between the cars, to air cylinders located under the bodies of the cars, which are effectively connected with the levers and rods forming the brake system on the cars. The demand for longer trains and heavier cars, together with the call for higher speeds, and perhaps more than all the desire for the use of air brakes on long freight trains, called for further development, and again Westinghouse with his wonderful inventive genius was equal to the demand. His next and greatest production was the quick-action automatic air brake, equally applicable to freight and passenger trains, which permits the control of the train from any car in a passenger train, and which in case of the train breaking in two, will automatically apply the brakes and safely bring both the separated parts of the train to a stop, and at the same time will give

the engineman warning of the separation of the train. The invention and adoption of this type of automatic brake has made a complete change in the demands upon, and the conditions surrounding, trainmen. Before its advent it was necessary for the trainmen to apply the brakes by hand, and therefore to be near or on the platform of the cars on passenger trains, and on freight trains to ride mostly on the roofs of the cars in all kinds of weather. This is now all changed, and not only is great risk to life and limb of trainmen avoided, but they are able, in severe and stormy weather, to be much of the time comfortably located in the caboose or the locomotive cab at their respective ends of freight trains, or attending more to the comfort of passengers on passenger trains. With the use and development of this invention has come, not only greatly added safety to trainmen, as well as to passengers, but the possibility, with perfect safety, of much faster speed and longer trains. This means shorter hours for the men, and also the possibility of handling more trains and cars; which with the natural development of business has given employment to many more trainmen, as well as more men in every other department of the railroad service and in the industries dependent upon it.

In the improved methods of heating cars, the railroad worker has largely benefited by what the inventor has done. In earlier times no heat at all was provided; then a step in advance was taken by furnishing small individual heaters, or foot warmers; next an advance was made to wood-burning stoves, followed by coal burners. These required constant attention, and made dirty and disagreeable work for the trainmen in providing the supply of fuel, and looking out for the accumulation of ashes. Now, thanks to the inventor, the trainman has a clean and dignified class of work, and together with the passengers can have the comfort of warm cars, heated by steam furnished from the locomotive. The terrible accidents which often occurred from fires in stoves which had been overturned by collisions have been done away with, and both railroad men and passengers can travel without apprehension in that regard.

Great beneficial results to the railroad worker have come through the invention of the improved pneumatic, or electrically operated switches. In large terminal switching yards, which are a perfect network of tracks, the life of the switchman was formerly one of great danger and exposure in severe weather; now, thanks to the inventor's skill, switches and signals at far distant points are safely and surely operated from a central station by skilled men comfortably housed and protected. By means of the interlocking features, the operators are

safeguarded against the possibility of a mistaken throwing of a switch which might cause a collision and possible loss to life and property.

The dirty and most disagreeable operation of coal handling, which plays such an important part in the work on the railroad, has through the work of the inventor been relieved of many of the unpleasant features. Where formerly the work called for large numbers of the lowest grade of labor, and the work was of the slowest and dirtiest character, now it is conducted with speed, economy, and comparative cleanliness, and the labor is performed with a higher grade of workmen and their duties are of a much more desirable character.

These, and many other of the mechanical and automatic devices brought out by the inventor in connection with railroad service, have rendered employees' lives safer, their occupations more dignified, their wages higher, their possibilities for earning greater, and the inducements to improve the mind by becoming skilled artisans rather than mere manual laborers have been much increased.

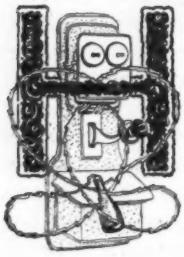
The inventors' success in raising the standard of accomplishments possible for men in the shops, in the freight houses, and in the offices even, by means of labor-saving machinery and automatic devices, is too well recognized and the improvements are too numerous to permit of individual mention in this paper. One of the greatest beneficial results of all that has followed the work of the inventor is the incentive given to the worker to improve his mind and skill, and so to become capable of taking a higher rank as a man and as a producer than was possible for the men of fifty years ago.

With the inventions has come less need for the mere drudge, and a greater call for a higher grade of workers, and this without reducing the number of men needed. For every new improvement seems to open up new fields for work, and new demands for employing men to meet the gradual but sure uplift in the general condition of the worker, both in the railroad service and in the general field of industry.

HYDRAULIC POWER APPLIANCES IN ENGINEERING INDUSTRIES.

By George H. Baxter.

Hydraulic generation of power, after a period of subordination to the steam engine and consequent decline, is coming again to the fore through the mobility given by electric transmission. The purpose of this number, however, is to display applications of power rather than generation of power, and it is to this aspect of hydraulics that Mr. Baxter addresses himself. Here he takes as his first theme the larger uses which have found their highest development in the machinery provided at the leading English ports. Even in this field the examples are so many that we have had to reserve for a following article the discussion of cranes and capstans, and to a later occasion still the miscellaneous uses of hydraulic tools and appliances in shops and works; confining the present review to the general elements of the question and the applications to coaling machinery.—THE EDITORS.



HYDRAULIC machinery may be divided into three classes, the first embracing all machines used for the production and transmission of power, the second those for transmission only, and the third—which may be generally described as "appliances"—those for the utilisation of hydraulic power. This last forms by far the largest class.

Before describing some of these machines and appliances in detail, it may be interesting to recall the most salient of the outstanding features in the history and development of hydraulic power.

In the latter half of the eighteenth century, before the advent of the steam engine, the chief source of power and means of transport was water. Industries were developed in towns adjacent to streams where sufficient fall was available for driving water wheels, and latterly turbines, for transmitting power to mills and factories, pumping water from mines, and for other purposes. These belong to the second class of appliances.

Water wheels are of three kinds, "overshot," generally used with falls of from 10 to 70 feet, "breast" wheels, with lower falls, and "undershot," wheels, where the falls range from 5 to 8 feet. In the two former, the power acting on the wheels depends on the volume of water and the height through which it falls, the efficiency varying

from 60 to 75 per cent. In the last, the power is dependent on the momentum of the water at the bottom of the wheel, the efficiency in this case ranging from 60 to 70 per cent. All wheels were at first constructed of timber, but the two first-named were greatly improved by Fairbairn, who introduced an improved form of bucket made of sheet iron, a system of ventilating the buckets, a modification of the breast to economise water, and the method of transmitting the power by fixing the large spur wheel to the arms instead of at the end of the axle, which, while strengthening the arms, allowed of a larger spur wheel being adopted and of driving the pinion on the main shaft direct without intermediate gearing. The old type of "undershot" wheel was much improved by General Poncelet, who, by fixing the best proportions of the diameter of the wheel to the height of the fall and improving the form of buckets, greatly increased the efficiency.

In later years turbines have been extensively used. In America, at Niagara Falls, in Switzerland, and in other mountainous countries, where an abundant supply of water having a comparatively high fall can be obtained, these machines have been adopted to work electric-generating plant for distributing power over very large areas at a very low cost. But these natural advantages can be profitably utilised only when the fall is within a reasonable distance of the places where power is to be distributed. In Great Britain, however, and in other countries where the natural supply of water is intermittent, and in dry seasons frequently ceases altogether, water power has been supplemented and, in many cases, entirely superseded, by steam power, and the old water wheel is therefore now regarded more as a relic of a past age than as an agent for transmitting power.

While the steam engine thus gradually displaced the water wheel, it also gave rise to a new system of producing and transmitting hydraulic power second in importance only to that of steam power itself. The hydraulic press, the principle of which was originally enunciated by Pascal about the middle of the seventeenth century, was first brought into practicable shape by Bramah about the year 1796, when he introduced an improved method of packing the hydraulic ram by means of cup leathers, which are used in much the same form at the present day. This invention greatly stimulated the development of hydraulic appliances, as it enabled much higher pressures to be used and largely increased the efficiency of the press.

From the original hand-wrought pump it was an easy transition to the application of steam pumping engines for working the hydraulic press, the principle of which was applied in the design of many differ-

ent kinds of tools and other appliances. Bramah first used steam pumping engines to produce and transmit hydraulic power for working cranes and other machines, and in a letter to Robert Mallet* in 1802, which, for want of space cannot be quoted at length, he concludes a very enthusiastic statement of the capabilities of this new power thus:—"I believe I shall have all the cranage of the London wet docks and warehouses to undertake, which will be the grandest job perhaps ever done." This prophetic letter seems to fortell the advent of the present system of transmitting hydraulic power from a central station to work cranes and other machinery, but as yet this could be done only in a "kind of way": there was no satisfactory method of regulating the pressure or the supply. In 1840† Armstrong proposed to pump water by a small steam engine, working continuously, into an elevated reservoir from whence a sufficient supply at constant high pressure could be obtained for machines working intermittently. Other devices were tried, such as air chambers and high towers, to give the pressure required, but these also proved unsatisfactory. Shortly afterward the development of hydraulic power received an enormous impetus by the inventive genius of Lord Armstrong, who devised the loaded accumulator, and also originated and brought to a very high state of perfection the modern system of hydraulic power transmission from a central pumping station through miles of piping to work hydraulic appliances of all kinds. Every seaport of any consequence throughout the world now has its docks equipped with at least one hydraulic power installation for working cranes, capstans, jiggers, coal-hoisting appliances, grain elevators, dock gates, sluices, swing bridges, and hauling machinery; every large railway goods yard, iron and steel works, forge, foundry, shipbuilding yard, engineering and boiler works, bridge-building and other constructive establishment, oil factory, tube-making works, etc., is provided with hydraulic appliances supplied with power from their own or from some co-operative or municipal installation. Hydraulic power stations for public supply have now been installed in several large towns for distributing power to work elevators, presses, and motors of many kinds in smaller industries. ‡The first of these to be established was at Hull, in 1877, then followed London in 1884, Liverpool in 1888, Melbourne in

* Professor Robinson, C. E., "Hydraulic Power and Hydraulic Machinery," p. 192.

† R. G. Blaine, M. E., "Hydraulic Machinery," p. 170.

‡ Paper by E. B. Ellington, M. E., on "Hydraulic Supply in Towns," Proceedings Institute M. E. See also Mr. Ellington's articles in THE ENGINEERING MAGAZINE, May and June, 1899.

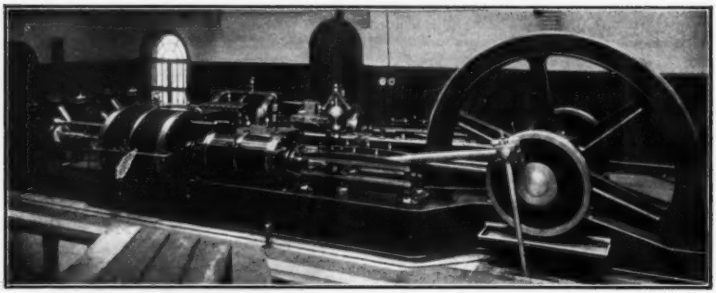
1889, Birmingham in 1891, Sydney in 1891, Antwerp in 1894, Manchester in 1894, and Glasgow in 1895. The working pressures range from 700 to 800 pounds in all except the two last-named cities, where they are 1,120 pounds per square inch. London has by far the largest system in the world. The London Hydraulic Power Co. has several stations each of about 1,200 horse power, and in 1895 had 85 miles of mains laid in the streets. War vessels, merchant steamships, dredges, barges, crane punts, and other craft are in a great many cases provided with hydraulic plant to supply power for working turrets, guns, presses, lifts, cranes, capstans, winches, windlasses, steering gear, grabs, etc., the water pressure being regulated by means of an accumulator loaded by steam pressure.

Special applications of hydraulic power on a large scale may be mentioned, but the space at our disposal will not admit of going into details. In some canals, such as that at Anderton,* barges, with the trough in which they are floated, weighing altogether 240 tons, are raised to a height of 50 feet, to connect the river Weaver with the Trent and Mersey Canal. This invention, designed by Sir Leader Williams to dispense with a large number of locks, effected a very great saving of canal water, using only 1.7 per cent. of the quantity required if locks had been employed. Similar lifts designed by the late Sir Edwin Clark have since been constructed for canals in France at Les Fontinelles near St. Omer, and in Belgium at La Louvière on the Canal du Centre, near Mons, where the load on each ram is about 1,120 tons, the height through which the trough containing the canal boat is raised being 50 feet. Floating graving docks, notably at Bombay, London, Malta, and elsewhere, worked by hydraulic machinery, have been constructed by which vessels up to 6,500 tons and drawing 30 feet can be lifted clear out of the water for examination and repairs. Slip docks, where large vessels are drawn up on a carriage for a similar purpose, are provided at many ports in Great Britain. Swing bridges over rivers and dock entrances, like those at the Tyne and the Clyde, and bridges of the bascule type, notably the Tower Bridge over the Thames, are operated by hydraulic power.

In the construction of the Forth Bridge many special hydraulic appliances had to be designed for bending, planing, drilling, and riveting the steel plates before and after erection. Some of the rivetting machines used in contracted spaces were so small that a pressure of 3 tons per square inch had to be employed to close the river. †In

* Professor Robinson on "Hydraulic Power and Hydraulic Machinery," p. 44.

† Professor Robinson on "Hydraulic Power and Hydraulic Machinery," p. 125.



FOUR-CYLINDER TANDEM-COMPOUND HORIZONTAL PUMPING ENGINES FOR HYDRAULIC POWER INSTALLATION.

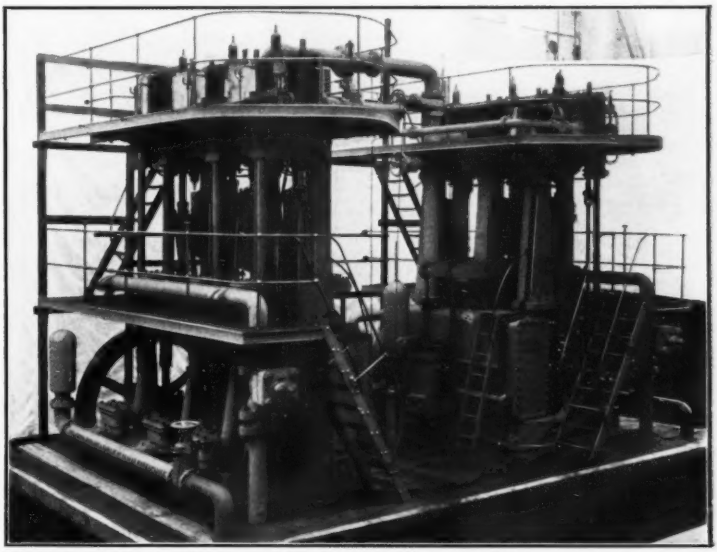
Sir W. G. Armstrong, Whitworth & Co., Elswick Works.

the great 1,700-feet spans the massive girders were built at a low level and raised as high as the top of St. Paul's Cathedral by hydraulic power. The continuous girders, nearly one-third of a mile long, used in the construction of the high pillars, carrying sheds, cranes, appliances, and workmen, the whole weighing in some instances more than 1,000 tons, were similarly raised. Hydraulic spades were used in excavating the foundations for the piers, in an electrically lighted diving bell 70 feet in diameter, and 90 feet below the sea. The history of the construction and erection of the Forth bridge, from start to finish, would form one of the most interesting and instructive accounts of the use of the most ingenious and varied descriptions of hydraulic power appliances, and we may give descriptions of some of these in a future article.

Hydraulic power is so largely used for dock machinery that a description of the various appliances for its production and utilisation would be sufficient to fill a fairly large book, but I shall endeavour to give, as briefly as possible, a few of the leading particulars of some of the appliances used in a typical modern dock equipment, such as that at Princes Dock in Glasgow harbour, where the greater part of the quayage is used for general cargo and the remainder for minerals.

Where room is available, the compound horizontal two-cylinder, or the four-cylinder tandem type of pumping engine with surface condensation, as shown in the photograph above, is most usually selected. The pumps in these engines are in line with and connected to the tail ends of the piston rods, and have buckets working in brass-lined barrels, the pump rod being half the area of the bucket. In this class of pump there is during each revolution a single suction at each outward

stroke, filling the barrel, but a discharge at each end equivalent to half its capacity, thus giving a practically continuous flow. But where space is limited and floor space is costly, the three-cylinder vertical triple-expansion surface-condensing engine of the marine type is frequently adopted. The illustration represents two sets of three such engines installed at Princes dock. The cylinders are 15, 22, and 36 inches diameter, the stroke 24 inches; each drives direct from the piston rod crosshead a single-acting hydraulic ram 5 inches in diameter working in a cast-steel gun-metal-lined pump chamber, and each set of engines can deliver 300 gallons per minute at a pressure of 750 pounds per square inch when working at 60 revolutions per minute. Steam is supplied at a working pressure of 150 pounds per square inch, by two multitubular boilers of the two-furnace marine type, each being 11 feet diameter by 10 feet long, the total heating surface of both boilers being 2,000 square feet. Two similar boilers, one of them being a spare boiler, have recently been added for the electric-lighting plant, and are so connected by steam piping as to be also available for working the hydraulic pumping engines. One boiler is generally off for cleaning while steam is on the other three.



VERTICAL TRIPLE-EXPANSION PUMPING ENGINE FOR HYDRAULIC POWER INSTALLATION.

Fullerton, Hodgart & Barclay, Ltd., Vulcan Works, Paisley.

Two accumulators are provided for the installation and placed side by side in a large tower adjoining the boiler room. Each is 20 inches diameter by 20 feet stroke, and the casings are loaded with sand to give a pressure of 750 pounds per square inch on the ram, which with its load weighs about 110 tons. One of these is the working accumulator, which is loaded slightly heavier than the other and has an automatic connection with the main throttle valve for cutting off the supply of steam when the ram is full-out. In normal conditions the lighter loaded accumulator is usually at the top of its stroke, full-out, and, to prevent its being forced too hard against the stopper beam by the heavier loaded accumulator while being pumped up, a shallow steel tub loaded with old iron is suspended by chains fixed to the beam, so that when the light accumulator gets near the top of its stroke the additional weight of the steel tub is taken up by the ram, thus increasing the load upon it and bringing it to rest before touching the beam. As an additional precaution, a loaded safety valve, worked automatically, is provided at the inlet to the accumulator cylinder.

The main pressure pipes, 7 inches diameter, are led from the accumulators to the southeast corner of the dock, and thence in a tunnel along the south quay, where the mineral traffic is worked, and at the west end are reduced to 5 inches diameter; from there they are led all round the graving docks, to provide water for working hauling engines for the dock caissons, division-gate rams, capstans, and sluices for the dock-pumping machinery. Branch pipes 4 inches diameter are led along each of the other quays in tunnels to provide a supply for the cranes. All the water pumped, except that used for the graving docks, is returned through pipes laid alongside the pressure mains, ranging from 8 inches down to 5 inches diameter. Hydrant boxes, spaced about 33 feet apart, having valves and branch pipes joining the mains, are provided along all the quays, the pressure connections to cranes being made either by wrought-iron walking pipes or flexible hydraulic armoured hose. Branches are also led to about 60 capstans distributed over the quays for hauling wagons and for shifting cranes when required. All the tunnels, cranes, and capstans are heated by gas when necessary during winter to prevent damage by frost, and for the same reason great precautions have to be taken to keep all exposed pipes and cylinders drained when not in use. Stop, momentum, air, and drain valves are also fitted to the main pressure pipes, which are arranged on the "ring" system where possible, so that the supply to any set of appliances may be maintained when one portion of the piping may have to be temporarily shut off for repairs.

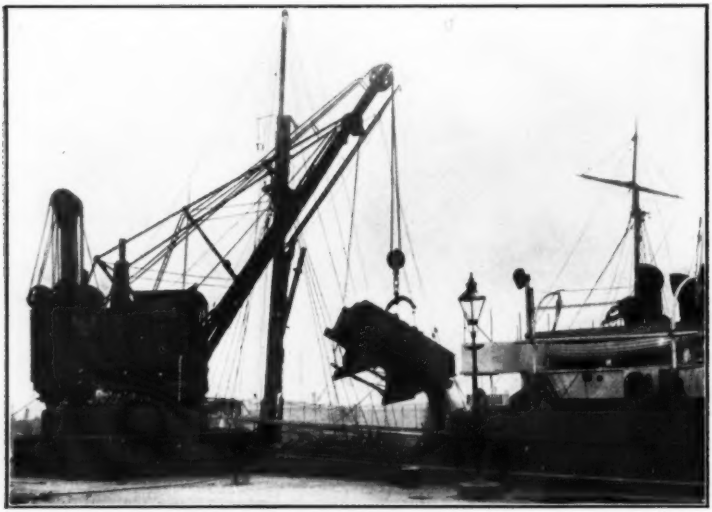
Coal Shipping Appliances, Cranes and Hoists.—On the Tyne, and at most of the northeast coast ports, coal is shipped by gravitation from hopper-bottomed wagons, which are run onto high staiths and emptied into shoots which conduct the coal to the hatches of the vessel. This is a cheap and expeditious process, but one which tends to break the coal whereby it is much deteriorated in value. At other parts, especially those in South Wales, the wagons have end doors, and are handled by cranes or hoists nearly all worked by hydraulic power.

When cranes are used, the wagon is run onto a cradle, lifted, and shoved over the hatch and then tipped, the coal being emptied directly into the hold. With hoists, the wagon is also run onto a cradle, lifted and tipped, the coal running down a shoot leading to the mouth of the hatch.

MODERN MOVABLE HYDRAULIC COAL-SHIPPING CRANE, LIVERPOOL HARBOUR.

The photograph illustrates one of two modern cranes erected at Liverpool by Sir W. G. Armstrong, Whitworth & Co., Ltd., and shows the process of shipping coal. The cranes are movable, can be placed to suit the hatches of the vessel being loaded, and are adapted to ship coals from trucks either of the end-tip or hopper type. The hoisting cylinder with its ram and pulleys is arranged inside the mast and pedestal, while the turning cylinders are placed at the back of the mast near the top, the tipping cylinder being arranged between them. With the

cradle shown, constructed by the same firm, turntables are unnecessary and the empty wagons are easily got rid of. In this appliance the crosshead carries a circular box provided with conical roller bearings on which the whole load turns. A sleeve connected to the middle of the cradle beam has a nut and washers in the upper end bearing on the rollers. The tipping chain has a bridle chain, attached to the lower end, which passes through the sleeve, thence to each end of the beam and, each part passing down over pulleys, is connected to the back end of the cradle at each side. The cradle seat is seen on the rails running underneath the pedestal of the crane.



FIXED COALING CRANE, QUEENS DOCK, GLASGOW HARBOUR. LOAD 20 TONS. LIFT 44 FEET.

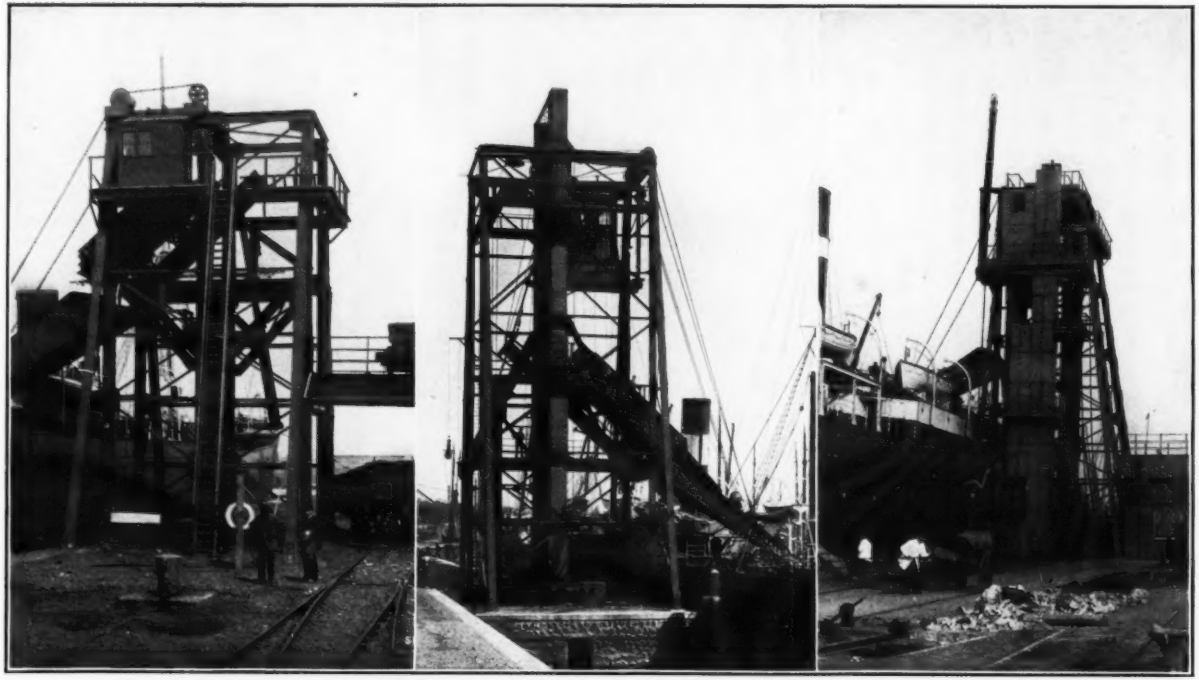
The illustration just above shows one of four fixed coaling cranes at Queens Dock, Glasgow Harbour. Each can raise loads of 20 tons through a height of 44 feet, and under favourable circumstances can ship in one hour from 25 to 28 wagons each containing 10 tons of coal. These cranes, erected in 1876, and originally worked by three-cylinder hydraulic engines with gearing and cup drums for the claims, were recently converted so that the hoisting and tipping are now effected by rams and multiplying pulleys, the original three-cylinder engines being used only for turning; the range of lift also was formerly only 36 feet. The result of the alterations was a great economy in the con-

sumption of pressure water, quicker speed, and greater range. Formerly the water used in lifting 30 feet, tipping, and turning through half a circle, was 355 gallons, and 13 wagons per hour was the most that could be shipped. For the same cycle of operations the consumption is for hoisting 109, tipping 15, and turning 23, a total of 147 gallons, a saving of 58 per cent.

The efficiency of most cranes for shipping coal is less than that of coal hoists or tips. As a rule, in the former the weight of the cradle, which is about 6½ tons in the case of that illustrated on page 885, cannot conveniently be balanced. In the case of a wagon weighing 6½ tons and carrying 10 tons of coal, the total load would be 23 tons. In a coal-shipping hoist, on the other hand, such as that recently erected at Glasgow, the whole weight of the cradle can be balanced within about 2 tons, so that to ship 10 tons of coal the gross load to be raised would be 18½ tons. In shipping 1,000 tons of coal, therefore, assuming the energy used for tipping to be the same in both cases, the crane would have to lift, slew, and tip a gross load of 2,300 tons, while the hoist would have to lift and tip only 1,850 tons—that is, 450 tons less. If the height raised is 40 feet, the energy saved by the hoist would thus be 18,000 feet tons. Besides, by means of the hoist or tip the work is done much more quickly and by fewer men.

A modern coal-shipping hoist consists of a high steel framework, open at the front and back, the sides being formed with guides for the cradle, which carries a platform onto which the wagon to be discharged is run and upon which it is secured by a chain. The platform is hinged at the front, and by raising it at the back end the wagon can be tipped, at any height, into the shoot. The latter is adjustable to any required height and angle, and can be housed close up to the framing when not in use, by means of the cradle which is provided with levers for carrying the heel of the shoot when moving it up or down. The shoot point is adjusted by chains connected to each side of the cradle.

In the earlier types of coal hoist, shown on page 888, the cradle is raised by two hydraulic rams of different sizes working in cylinders set in a deep well near the edge of the quay, the smaller ram balancing the cradle being always open to the pressure in the mains. The tipping cylinder is fixed to the cradle and oscillates on trunnions, the ram being connected to a pin at the back of the tipping platform. Pressure is conveyed to the tipping ram by a telescopic pipe arranged alongside the cylinders and led through the trunnions, or by walking pipes, but the former is the better arrangement. In a modification of this type some hoists were provided with four rams of different areas, which



HYDRAULIC COAL HOISTS, OF EARLIER AND LATER DESIGNS.

On the left is the early design mentioned on page 887, with the cylinders set in a well near the edge of the quay. The central figure shows the newer form mentioned in the following paragraph, with all working parts above the quay. Both of these were built by Sir W. G. Armstrong, Whitworth & Co.
On the right is the suspended-cradle type for high lifts, Princes Dock, Glasgow harbour.

could be used in different combinations so as to adapt the consumption of water to the load to be raised, but it seems rather complicated.

In later designs, in which all the cylinders and other working parts are above the quay and thus admit of such hoists being movable, there are two hoisting rams at each side of the guides in the framing, bearing on a beam to which the cradle is connected. The smaller rams act as balances to the cradle, and being always open to the pressure from the mains, use no water, and the corresponding pairs are arranged diagonally on plan. In this design, the tipping is effected by a cylinder fixed to the side of the framing and a ram with multiplying pulleys, chains or ropes being led over pulleys at the top of the framing and thence downwards to the beam of the tipping platform. Where the range of lift exceeds 40 or 42 feet the rams are sometimes made telescopic, the lower rams being provided with stuffing boxes into which the upper arms work.

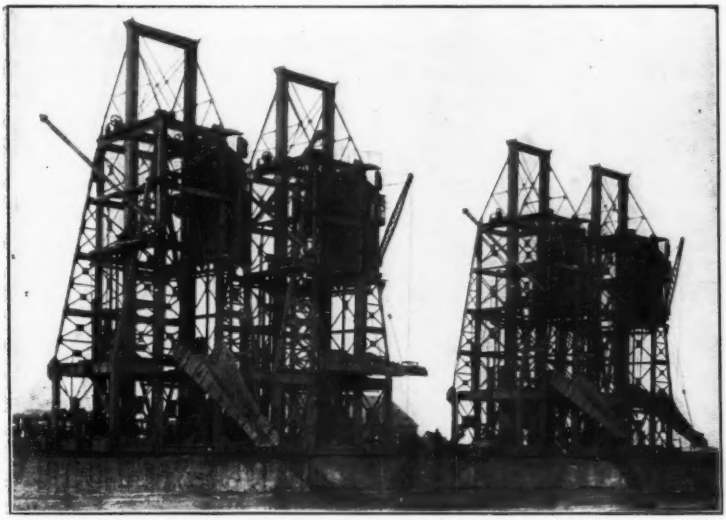
Another design for still higher lifts is the suspended cradle type of hoist, one of which, recently erected at Princes Dock, Glasgow Harbour, and probably the highest in Great Britain, raises loaded wagons weighing more than 25 tons to a height of 50 feet by means of two rams, one for 20 tons, and the other for 5 tons additional. In this case the 20-ton hoisting cylinder with a balance cylinder alongside is fixed to one side of the framing, the rams connected to the same crosshead acting downwards when hoisting, thus assisting to balance the weight of the cradle and enabling their size to be reduced to the least possible. These actuate a set of multiplying pulleys, the chains being led over the top of the framing, passing downwards, and being secured to the cross beam of the cradle, which is thus suspended and which runs in guides on each side. An additional cylinder and ram to lift 5 tons is fixed to the opposite side of the framing, and the chains can be attached to the cradle beam as in the case of the 20-ton lift; but hitherto the latter has been sufficient to deal with any wagons brought to the hoist. The tipping cylinder is arranged in line with and on top of the hoisting cylinder, the ram working upwards and also carrying multiplying pulleys and chains led over the top of the framing to the tipping beam of the platform. The shoot is adjusted by chains temporarily connected to the cradle when required, as already described. This hoist is provided with the usual anti-breakage box and a crane to work it, the box being capable of holding 3 tons of coal. This is used to load about 50 or 100 tons of coal which is lowered into the hold by the anti-breakage crane and piled up in a heap under the hatch, to save breakage when the coal is afterwards discharged direct from the shoot.

Regulating doors, fitted at the point of the shoot, are used for filling the anti-breakage box and for regulating the flow of coal. After being emptied, the wagons are run off the cradle to a high-level inclined railway whence they reach the quay level, descending slowly by gravitation, the gradient being about 1 in 70. In this hoist the speed of lifting is 90 feet per minute, and with a lift of 23 feet 6 inches, 45 wagons, each containing 12 tons of coal, can be loaded per hour. The quantity of water used in raising the cradle with a load of 20 tons to a height of 50 feet in 225 gallons, for a lift of 25 feet 113 gallons, and for tipping to an angle of 45 degrees, 39 gallons.

For quick working the ideal arrangement is that at Barry docks, where the trucks run on by a slight gradient, sloping downwards towards a point about the middle of the hoist, thus giving the least amount of lifting and lowering, and are run off by a similar gradient sloping from the hoist. With this arrangement wagons can be weighed, brought on the cradle, discharged, tared, and run off, at the rate of 60 per hour.

South Wales is the principal centre where coal-shipping machinery of this kind is most used. At Cardiff, Penarth, Barry, Swansea, Newport, and Port Talbot many coal hoists are erected similar to those already described.

At Cardiff there is a very large installation of coal-shipping hoists and cranes. Among the latter, at the Roath dock are eleven sets of the Lewis-Hunter eighteen-ton movable cranes with luffing jibs, ranged along the front of the quay for a length of 1,800 feet and each capable of handling 10 tons of coal at one lift. Behind the cranes is a line of rails running parallel with the quay, with deep pits formed at frequent intervals, provided with hinged platforms on to which the wagons are run. The platforms are lowered at the free end by hydraulic power, and the coal emptied into large iron or steel boxes having pyramidal shaped bottoms which have a connection sliding through the top of the box fixed to a chain operated by the crane. Other two chains acting independently of the first are connected to take the weight of the sides and upper part of the box. When filled, the box is raised, swung on board, and lowered into the hold, being carried by the three chains. When landed, the two side chains raise the box clear of the loose bottom and the coal is slowly emptied by sliding into the hold without any fall whatever. The greatest and only fall the coal can possibly have by this system is 5 feet, when tipped from the truck into the box, and this applies only to the first few lumps, after which it is obvious that as the box fills the fall is reduced until it becomes nil. With the old



MOVABLE COALING HOISTS, PENARTH DOCKS.
Built by Fielding & Platt, Ltd., Gloucester.

system the coal is tipped into a shoot with a fall of 4 feet; it then has to roll down over the shoot, 24 feet long, after which it has an actual drop of between 20 and 30 feet according to the depth of the vessel.

As the box is twice raised during the operation of loading the contents of one wagon of coal into the hold, somewhat more pressure water may be used than by the ordinary coal tip but the gain in the increased value of the cargo by this system will far more than compensate for the difference in the amount of water consumed.

These cranes being movable, three or four can be worked simultaneously, and 9,234 tons have thus been shipped into one vessel, the Samoa, in the net loading time (after deducting stoppages for coal), of 28 working hours, an average of 330 tons per hour, while in the case of another, the Iran, 9,213 tons have been loaded by four cranes in a net loading time of 26½ hours, an average of 347 tons per hour.

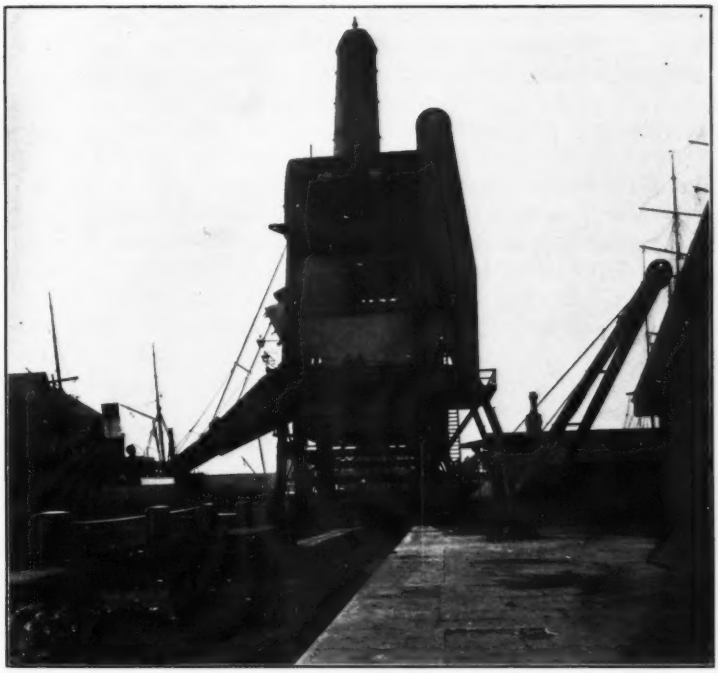
A very large dock about half a mile long, 800 to 1,000 feet wide, and 50 feet deep, is now being constructed at Cardiff and the south quay is intended to be laid out for the shipment of coal by the Lewis-Hunter process, the cranes being adapted to deal with 20-ton wagons in lieu of those now in use (10 tons).

At Penarth dock, there is a group of four movable coaling hoists made by Messrs. Fielding & Platt, Ltd., Gloucester and shown in the

illustration, which deserve special mention on account of their rapidity of working. These are capable of being rapidly moved to suit the hatches of a vessel by a powerful hydraulic hauling engine. Every part of the machinery in the hoist as well as the cradle, the tipping, working of the shoots, and movement and working of the anti-breakage boxes and crane, is controlled by one man from a high cabin. Each hoist was required to fulfil the following conditions:—A loaded 10-ton wagon having been placed on the cradle had to be lifted 45 feet from the quay, the contents tipped into the shoot, the wagon lowered to the quay level and run off the cradle, within 30 seconds; and this was successfully accomplished. The speed of lifting is 180 feet per second. Each hoist is fitted with two anti-breakage cranes and boxes which are capable of boxing as rapidly as the coal can be delivered into the shoot. Automatic apparatus is provided for stopping the cradle in hoisting and lowering. The shoots are made to radiate 5 feet on either side of the centre line so as to enable them to assist and minimise the trimming. Platforms with two turntables, one for the empty and the other for the full load, with 2-ton capstans at each, are provided for each hoist. The pressure water is conveyed to these tips by means of two mains each 8 inches diameter, so arranged that in case of failure of either one or other it is possible by an arrangement of stop valves and branches connecting them at intervals to cut out any section of these pipes and so turn the water past the defective section. The water is returned through a 12-inch main to the pumping engines. Two large accumulators are fitted on the pressure mains, one at the engine house and the other beyond the tips. The pressure water is pumped by three pairs of compound horizontal tandem engines collectively capable of delivering 1,440 gallons of water per minute, at a pressure of 750 pounds per square inch.

These hoists are specially constructed to enable vessels of 2,000 to 3,000 tons dead weight capacity to enter the dock, be loaded up, and sail the same tide, within a few hours of high water, and are probably the quickest loading coal tips in Great Britain, if not in the world.

Recently some exceptionally rapid work was performed at these tips, no less than three steamers having been loaded with full cargo and bunkers and despatched to sea between 6.40 a. m. and 4.55 p. m. and practically therefore on one tide. The Gatesgarth commenced at 6.40 a. m. and took in 2,291 tons—there was the usual half-hour interval for breakfast, and the work at commencement was comparatively slow owing to the frost—but the vessel completed her cargo and bunkers at 10.20 when she was hauled out of berth. The Dalegarth then



HYDRAULIC BARGE HOIST FOR SHIPPING COAL, GOOLE, YORKSHIRE.
ELSWICK-BUILT.

went into berth, commenced loading at 11.05 and finished both cargo and bunkers (2,201 tons) at 1.55 p. m. She then made way for the Throstlegarth, which commenced loading at 2.15 and took in her full complement of cargo and bunkers (2,107 tons) by 4.55 p. m.

As each steamer before commencing cargo took some time in shipping her bunker coal, which could only be shipped over one tip, the time of actual loading was appreciably less than the foregoing figures indicate.

The aggregate quantity shipped at this one berth between 6.40 in the morning and 4.55 in the evening was thus 6,599 tons, and some idea may be formed of the labour thereby entailed when it is stated that in addition to haulage to and from the tips, 676 wagons had to be lifted to a height of 30 feet above the level of the quay and returned to the quay level.

At Goole, in Yorkshire, there are three barge hoists worked by

hydraulic power, similar to coal-shipping hoists for wagons. These are shown on page 893 and are used for tipping coal from compartment boats into steamers for export. The boats, each of which holds from 23 to 25 tons of coal, are floated onto the cradle, then lifted, and turned over sideways, so that the contents fall into a shoot by which the coal is conducted into the vessel's hold.

Another interesting example of wagon hoist is shown in the illustration just below of a steam ferry boat for the River Volga for taking trains of loaded railway trucks across the river. Owing to the great variation in the water level it was necessary to provide some arrangement for transferring the trucks to the barge from the fixed railway approaches on the shore, and this was done by means of two hoists fixed on the end of a barge, each having a cradle worked by hydraulic power which can be raised to any required height, and on which the trucks are run one by one.

VOLGA FERRY WITH HYDRAULIC HOIST FOR RAISING RAILWAY TRUCKS TO THE LEVEL OF THE SHORE APPROACHES. BUILT AT ELSWICK.

Hydraulic power is convenient, reliable, easily controlled, and is thus admirably adapted for dealing with very heavy loads such as canal lifts, floating docks, and bridge-building and working machinery such as that already referred to; also for heavy forging work, stamping presses, flanging, rivetting, and plate-bending appliances. Hydraulic cranes, hoists, and capstans are efficient and economical when working at the full loads for which they are designed, but efficiency falls off rapidly as the loads become less. It should be noted that in cranes as much water is used to lift the empty hook as to lift the full load, and in capstans the same quantity of water is used whether the capstan is running idle or pulling ten or twelve loaded wagons. Although

attempts have been made to get over this difficulty by making the cranes compound, as described on page 889, by using telescopic rams for two or even three powers, except in special cases these are only a makeshift. It is not convenient to have to change from one power to another to suit the various loads, especially when this has to be done in the dark, and frequently, rather than change to a lower power, the crane driver keeps using the larger one, thus wasting water. The same remarks apply to coal-shipping hoists, where in Great Britain loaded wagons vary in weight from 13 to 25 tons. Capstans use a lot of water and are very inefficient at low powers, that is with light loads, such as hauling single empty wagons. Some attempts have been made to reduce this loss by making the capstan head of two different diameters, but these have been found inconvenient.

Chiefly on account of this loss of efficiency and of damage to hydraulic plant by frost during winter in the more northern latitudes, and also on account of the greater difficulty of handling hydraulic connections and the greater cost of their maintenance, electric power is now very largely coming into use for working cranes, capstans, and other dock equipment. The cost of power used in discharging, say 1,000 tons of cargo by hydraulic cranes, increases in inverse proportion to the loads raised; that is, the smaller the loads the greater the cost for power. In loading the difference is still greater in favour of electric power for, while by the hydraulic crane the cost would be the same as for discharging the same quantity of cargo, the cost of loading by an electric crane of the same power would be, roughly speaking, from one-half to one-third of that of the hydraulic crane, because in loading, the empty hook would be raised as much as the loads would be in discharging, and for this the maximum power would be used by the hydraulic while the minimum would be used by the electric crane. In this connection it is worth while to remember that 1,000 gallons of water at 750 pounds per square inch used per hour is the equivalent of 6.52 units of electricity. Again, if it be desired to compare electric with hydraulic power as used in any of the appliances referred to, a useful formula is $WH = G \times P \times .0087$, i. e., the watt hours per cycle = gallons used per cycle multiplied by the hydraulic pressure per square inch $\times$ .0087.

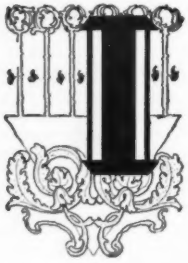
Whatever may be the future of hydraulic power, it is quite certain that for many purposes it will still be more suitable than electric power.

The author desires to express his thanks to Sir W. G. Armstrong, Whitworth & Co., to Messrs. Fielding & Platt, Ltd., and to Messrs. Fullerton, Hodgart & Barclay, Ltd., for the use of photographs.

LABOR-SAVING MACHINERY IN FOUNDRY OPERATIONS.

By Dr. R. Moldenke.

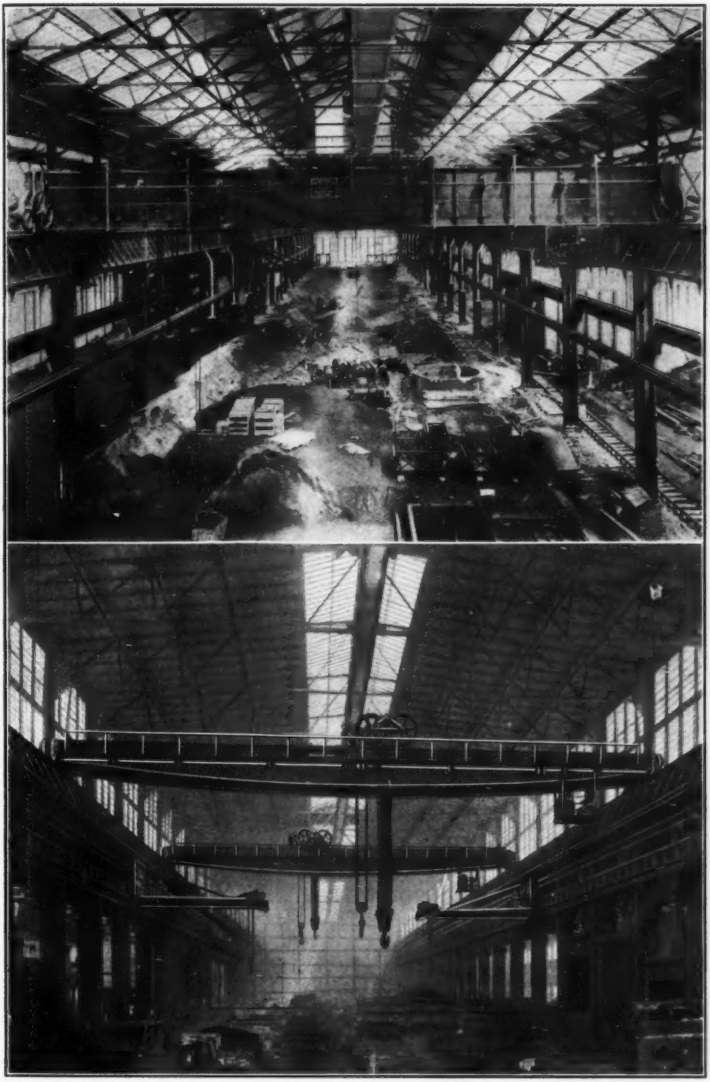
Dr. Moldenke's text and the accompanying illustrations are ample to show that there is no lack of labor-saving machinery applicable to the foundry, and some progressive foundries where every advantage of this sort is seized. In the main, however, the foundry appears the least advanced of the metal trades. Dr. Moldenke makes a very practical, logical, and orderly presentation of the money-saving possibilities which are open in this line.—THE EDITORS.



IT may as well be freely confessed at the outset, that we have still much to do in the way of installing labor-saving devices in the foundry. Yet what has been done already plays so important a *rôle* that the effect is readily seen when it comes to compare quotations for work received from competitive shops.

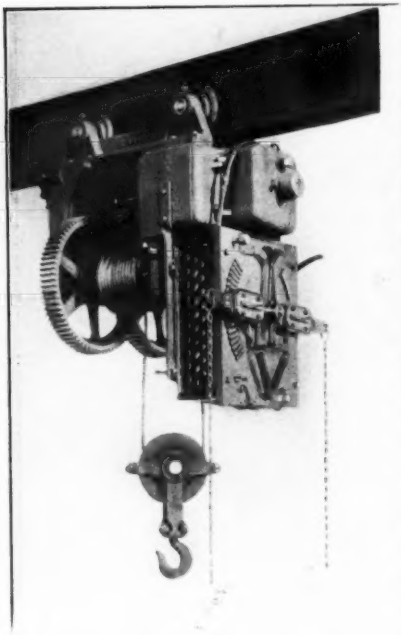
Two things there are which militate against the general introduction of labor-saving appliances in the foundry industry:—these are the active hostility of the labor employed, which sees in them a means to cutting down earnings, and the inertia of the foundryman himself, who hates to be forced out of the beaten path. These two points, which are all-important in connection with what is to follow, deserve a little further ventilation.

The laborer who earns his dollar and a half a day does not care much whether he is wheeling sand or preparing the loads for the electric traveler. The skilled moulder, however, does care, if this laborer is placed at a moulding machine, which reproduces the moulder's own particular work at a little over half his pay. Hence his opposition. Strike after strike can be placed to the account of the moulding machine. Where the management of a "union" shop has had the temerity to insist on using this labor-saving device, and either forced or by other means secured its retention in the shop, straightway is the production limited to something like a day's work by hand. The owners of the "open" shop naturally reap the advantage, as they have a goodly string of "Hungarians" waiting an opportunity to manipulate a machine. As a natural consequence, the "open" shop



CRANE EQUIPMENT FOR THE FOUNDRY. OVERHEAD TRAVELERS AND AUXILIARY JIBS.

Above is shown a general view of the crane arrangement in the Westinghouse foundries at Trafford City. The cranes are by Wm. Sellers & Co. Below is the main foundry of the Allis-Chalmers Co., with Pawling & Harnischfeger cranes. The large travelers are each of 40-tons capacity, with 10-ton auxiliary hoist.



will hereafter be less of a curiosity; all the signs point that way. The governing body of the Moulder's Union has gone on record in favor of the moulding machine, demanding, however, that their members be used to bring out "its best possibilities." More need not be said on that question.

On the other hand, the foundryman of the generation just passing has been most slow to act. He is afraid of improvements, even though he sees his margins being cut down by keener competitors, who do not hesitate to invest in whatever means labor saving. It is a sad commentary of the times that the associations of foundrymen which make education their principal object, and thus equip their members for industrial leadership, are starving; while the trade organizations to fight labor, instead of educating it up, have "funds to burn." The managers of the coming generation, if educated properly along technical as well as business lines, will act differently, and from them we await the advance in the industry which labor-saving devices used in their fullest development alone will give.

2-TON ELECTRIC OVERHEAD TROLLEY HOIST AND GEARED CRANE LADLE.
Northern Engineering Works.

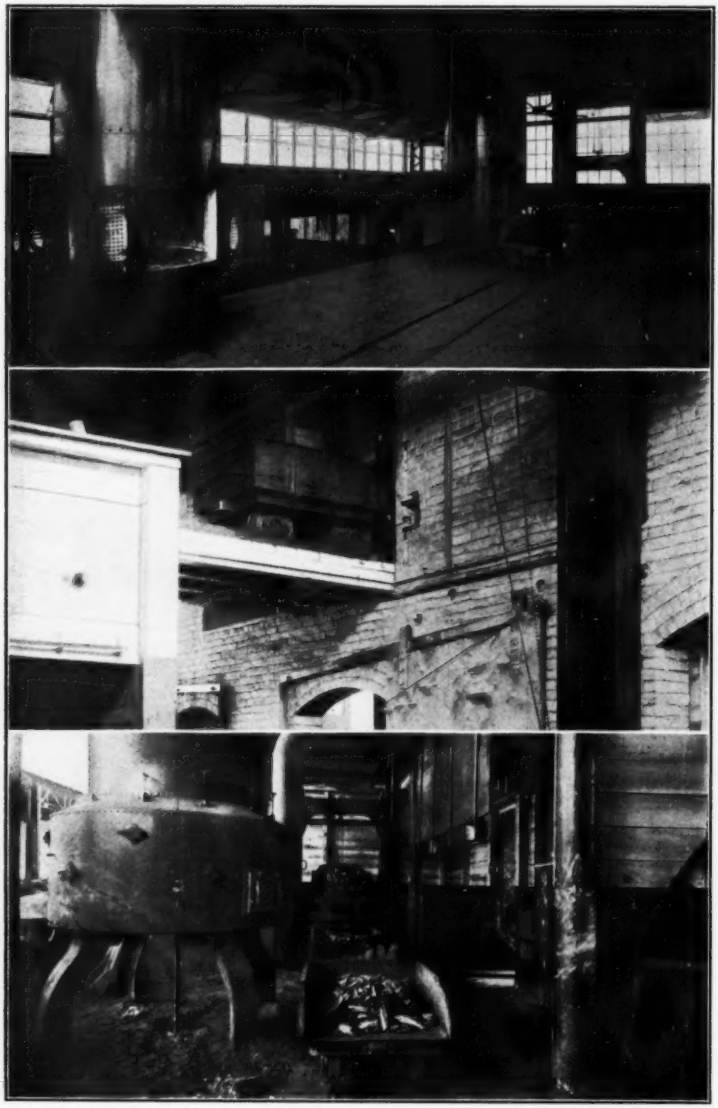
The practical application of the foregoing would seem to lie in the joining of effort on the part of associated bodies which oppose the organized tyranny of labor with those whose aim is to

educate both labor and owners. Only by taking away the power for mischief from the ignorant, and giving the intelligent individual a chance to better himself by his own effort, will conditions be brought about which are at once tolerable and fair.

INDUSTRIAL RAILWAY IN THE FOUNDRY OF THE BRITISH THOMSON-HOUSTON CO., LTD., RUGBY.

The ladle cars are used for transporting melted metal, and the flat-topped cars for handling pig iron and castings. The C. W. Hunt Co., West New Brighton, N. Y.

The first place to look for labor-saving devices is in the yard arrangement of a foundry. Recent examples as well as old establishments remodeled are so arranged that raw materials enter, and products leave, with as little handling as possible. When coal, coke, sand, and the like can be dropped through a trestle into bins, and be subsequently taken away through chutes directly into industrial cars, an important economy will have been affected. Pig iron, if thus dropped from a trestle for piling below—or better still, if thrown from the car directly upon the charging platform, and used—would require a minimum of handling. This, however, is possible only in small institutions. The larger foundries must pile up a considerable stock of pig iron. There are still "back numbers" where the cupola charges are passed up hand to hand, but the majority of American foundries are



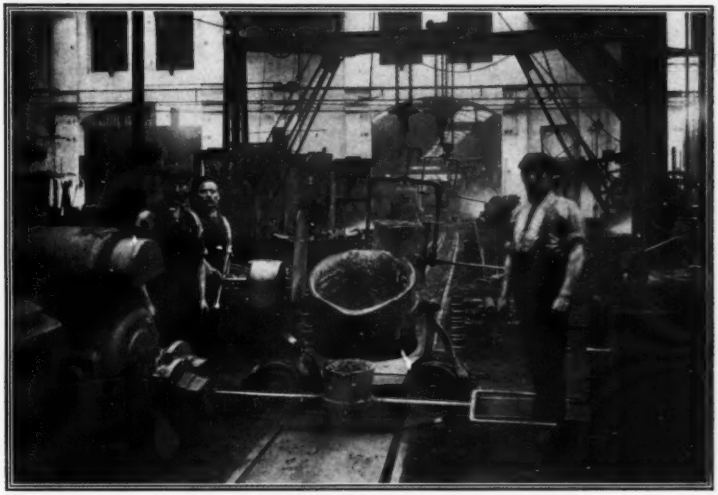
CUPOLA-CHARGING SYSTEM, HYDE PARK FOUNDRY OF THE B. F. STURTEVANT CO.

At the bottom are seen the cars, ready to go up to the charging floor. In the middle is one of the charging cars just passing between the elevator and the charging floor. At the top is the charging floor, with the car at the cupola-charging door.

now equipped with hoists or elevators. When the quantity melted is, say, 25 tons daily, a single hoist, run by hydraulic power, serves very well. Where 50 tons and more is the rule, a double, balanced, electric or steam elevator is preferable.

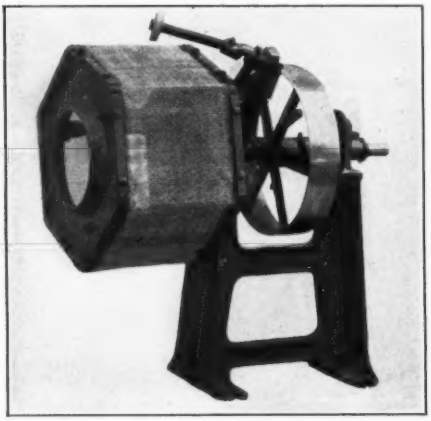
To show what is done in the way of labor saving in the metal yard, the following instances are cited. One establishment uses a very large traveler in the yard, covering all the piles of pig iron. This traveler is used to pick up the irons for the mixture, putting them into a series of buggies. A string of these is then pulled up an inclined plane along the side of the foundry, upon the charging platform. This, while somewhat roundabout, is still a very effective labor-saving device. It would be better yet to lift the charges upon an extension of the charging platform covered by the crane, and then transport the cars to their destination.

Another instance is that of the new Allis works in Milwaukee, where a similar yard crane takes up the pig iron and scrap and loads it into portable hoisting skips; these are then shot up directly in front of the cupola door, and the contents tilted in. The practice is strongly suggestive of blast-furnace methods, and it is stated that the melting is quite uniform. Perhaps it might be a good idea to add to all these systems a crane scale to weigh the iron picked up, and to do the



HUNT'S LADLE CARS AND INDUSTRIAL RAILWAY, IN THE FOUNDRY OF RUSTON, PROCTOR & CO., LINCOLN, ENGLAND.

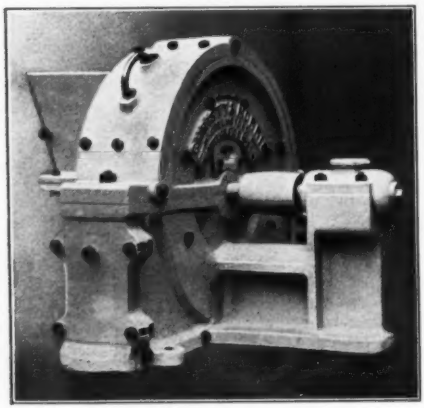
The C. W. Hunt Co., West New Brighton, N. Y.



EBERHARDT'S AUTOMATIC SAND SIFTER.

picking up with a large electromagnet, such as is used in some of the large sheet mills. A minimum of labor would be then required for the preliminary foundry procedure.

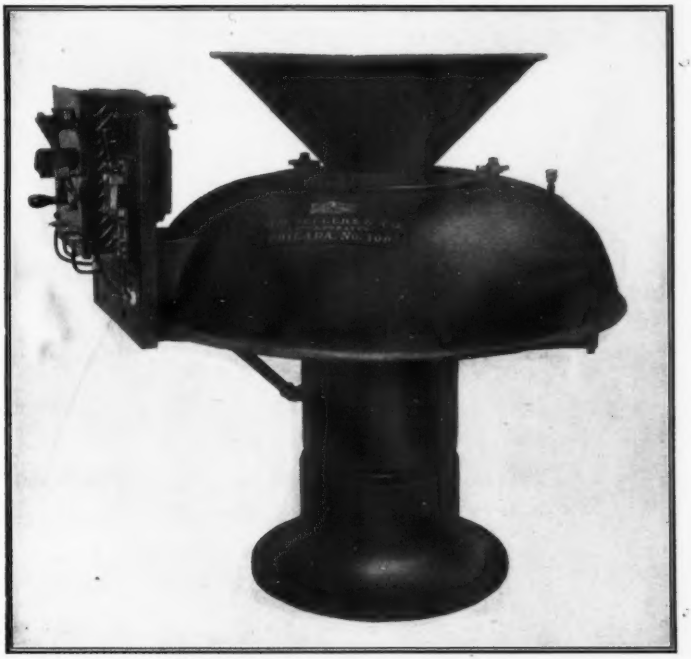
Even in the manufacture of sash weights we find metal conveyors used. It seems incredible that just this advanced method should prevail in the shops which act as the scavengers of the foundry industry. Yet we see tin cans, etc., slowly wending their way upward, and directly into the top of the cupola, alternating occasionally with fuel and flux, and this going on continuously. Almost a constant stream of metal comes from the cupola spout, and is poured into the most primitive of moulds, four or five men turning out a lot of tonnage, and the metal containing nearly every common metal under the sun. Occasionally we see this system used also where heavy tonnage is required for but little moulding, as for instance in the manufacture of ingot moulds. A chain conveyor which takes up the single pigs into the door of the cupola is quite a labor-saver, the coke usually being sent up another way.



DISINTEGRATOR FOR FOUNDRY USE.
Christy & Norris, Chelmsford.

From the yard, so arranged that interference between incoming and outgoing material is avoided as much as possible, and the most economical distribution of the stock is obtained, we come to the general arrangement of the buildings. Here also much labor

can be saved by making the course of the material through the shops a most direct one. Wherever possible the industrial-railway system should be used, and if standard-gauge railway facilities are at hand, a spur right into the main foundry is a money saver. All important shops now have this, and castings are lifted from the floor by the crane, weighed on it, and deposited for shipment without rehandling. Turntables at all crossings should be provided, so that the system of trackage in the foundry and adjacent buildings may become as flexible

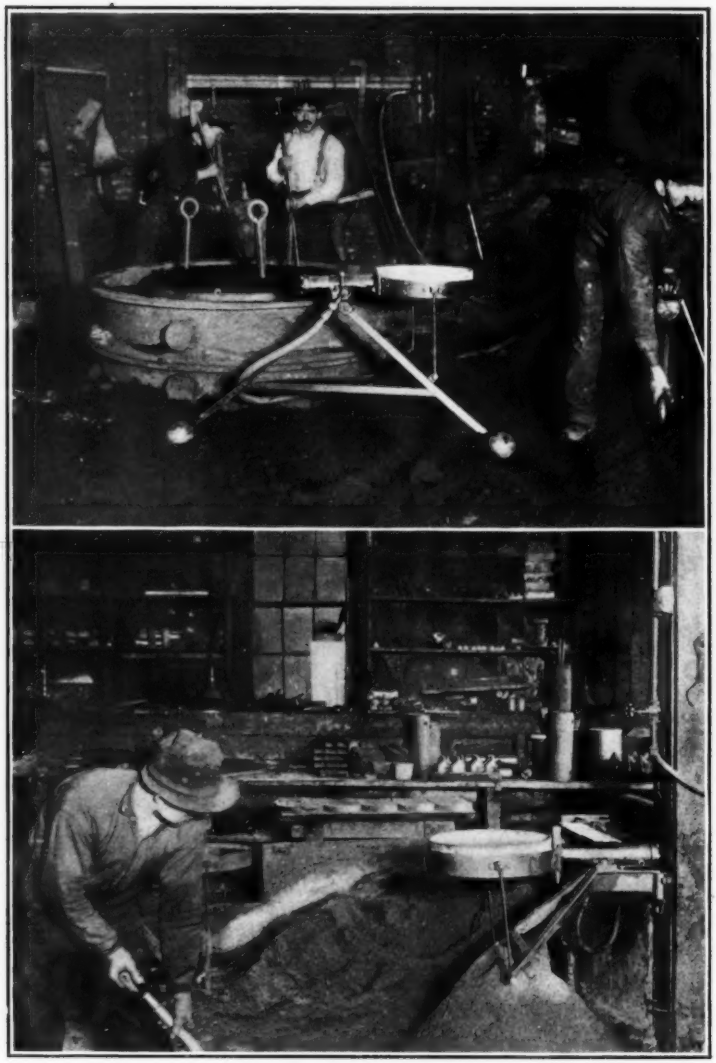


MOTOR-DRIVEN CENTRIFUGAL SAND MIXER.

Output about 5 tons an hour, and of better quality than can be obtained by any system of hand mixing. Wm. Sellers & Co., Philadelphia.

as possible. Large industrial establishments are now introducing the electric locomotive, and the future will see some of these in our foundries also. It goes without saying that plenty of light, air, and heat in winter, also constitute a valuable asset in any establishment, being in fact labor savers.

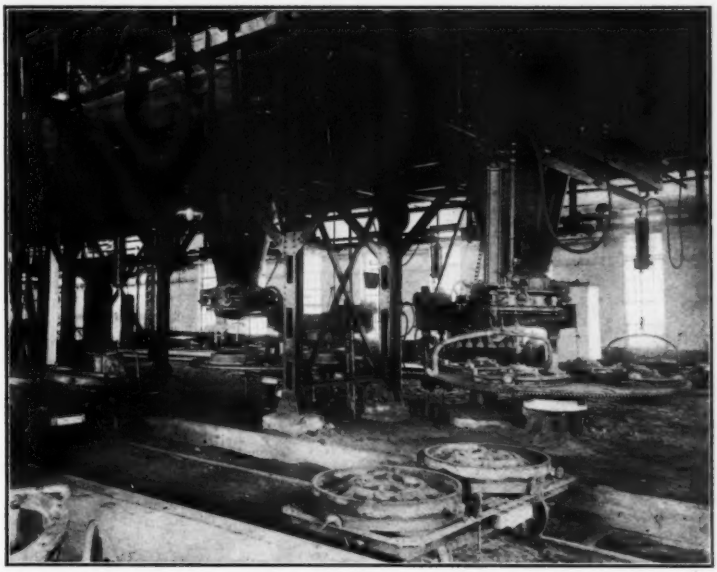
Coming now to the moulding department proper, we still see in most foundries the old way of tempering the moulding sand. Occa-



THE HANNA PNEUMATIC SCREEN SHAKER, TRIPOD AND POST TYPES.

Especially adapted to shops where the work is too diversified to allow of central screening. A valveless piston, working in a cylinder, is attached directly to a holder arranged for an ordinary 16-inch riddle. Uses about 12 cu. ft. free air per minute at a pressure of 80 lbs. Hanna Engineering Works, Chicago.

sionally we find an establishment where a centrifugal mixer improves on this hand tempering, at least for the better grade of castings, and for all the sea-coal facing mixtures. The reduced scrap heap of the trimming room soon gives evidence of the wisdom of this additional treatment. Then we find also automatic sand sifters, usually run by pneumatic power and in connection with a moulding machine, which are also wonderful labor savers. They imitate closely the action of a man riddling the sand pile.



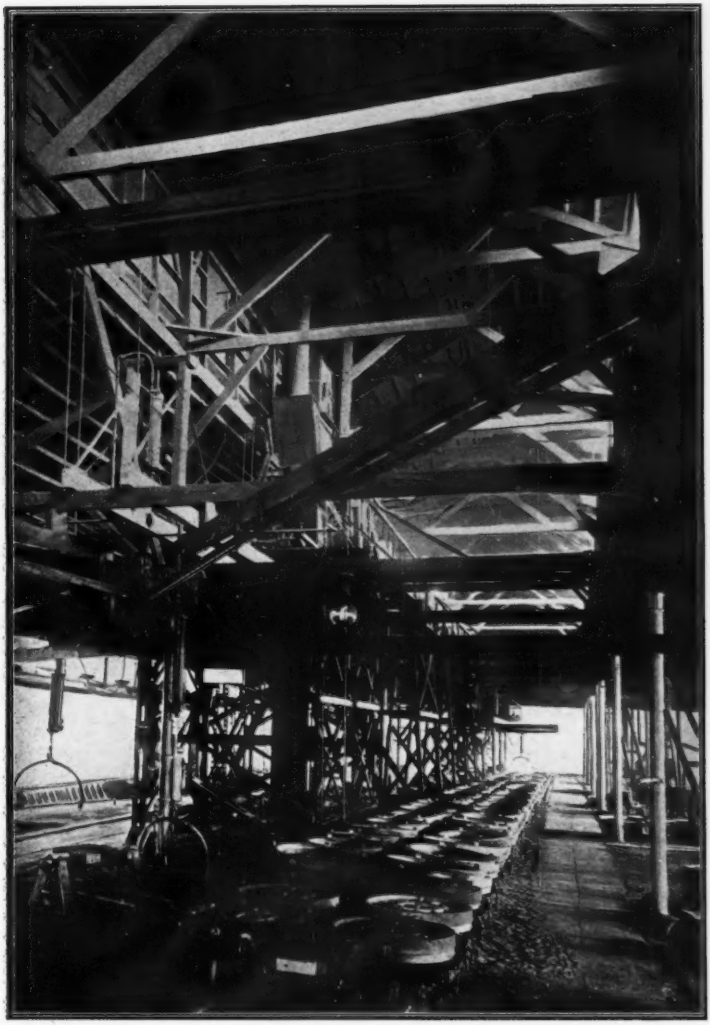
SAND-HANDLING PLANT, TERRE HAUTE WORKS, AMERICAN CAR & FOUNDRY CO. MOULDING END.

It is in the specialty shops that we must look for the greatest advance along this particular line. Several works of importance have systems so complete that only the dumping in of new sand is done by manual labor. Here is an outline of the general arrangement:—The sand from the castings just dumped out, usually taken to the end of the system and thus cooled a little, passes through a screening machine to take out the lumps, iron shot, etc. The addition of iron bars tumbling around with the screen helps to break up many of the lumps and thus saves working them up subsequently. As the sand comes from the screen it is wetted down with a measured quantity of water, and then passed through a centrifugal mixer. The tempered sand

PART OF CONTINUOUS MOULDING SYSTEM, WESTINGHOUSE AIR-BRAKE COMPANY'S FOUNDRY.

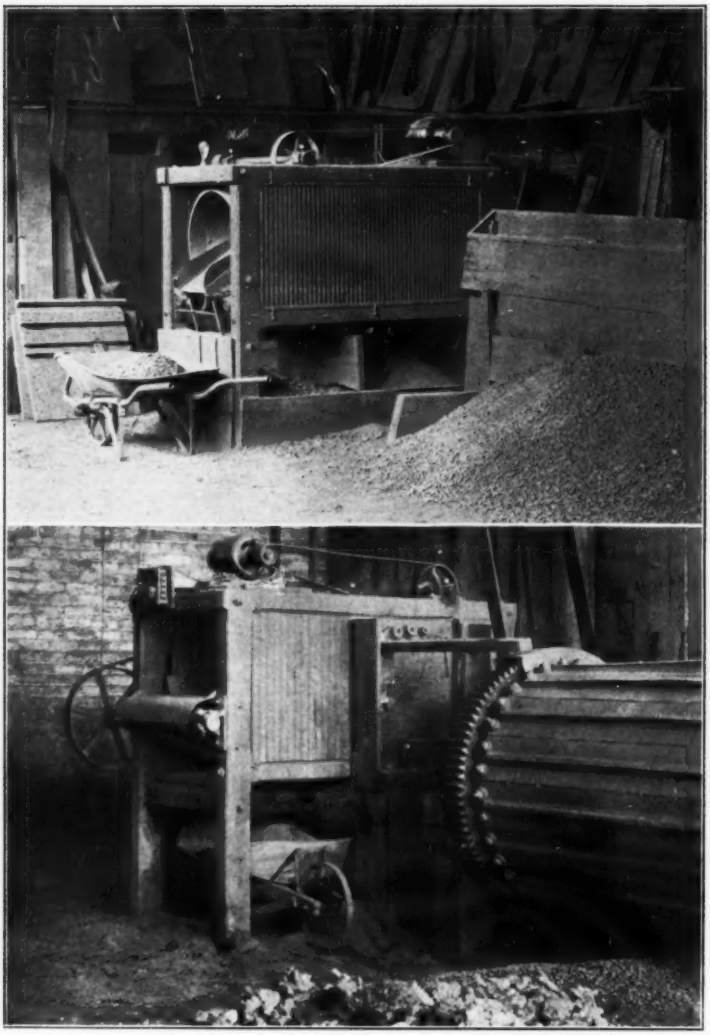
237-foot center conveyors, single-strand chain, sprocket-wheel terminals. The sand is elevated to overhead conveyors and delivered to chutes seen in the right background, leading to the moulding tables. The mould being made, the flask is placed on the conveyor, passes to the pouring station near the cupola, and thence at a low speed, cooling as it goes, to the other terminal. There it is emptied upon screen bars, the sand passing through and eventually back to the elevating and conveying machinery. Link-Belt Engineering Co., Philadelphia.

now goes into a bucket conveyor which takes it up to the distributing level, over the moulding floor. Here it is dropped into a reciprocating conveyor, which gradually passes it over the chutes from which the moulding machines or moulding floors are supplied. This system, with but little modification, is in operation in several places. It could



SAND-HANDLING PLANT IN CAR-WHEEL DEPARTMENT, TERRE HAUTE WORKS, AMERICAN CAR & FOUNDRY CO.

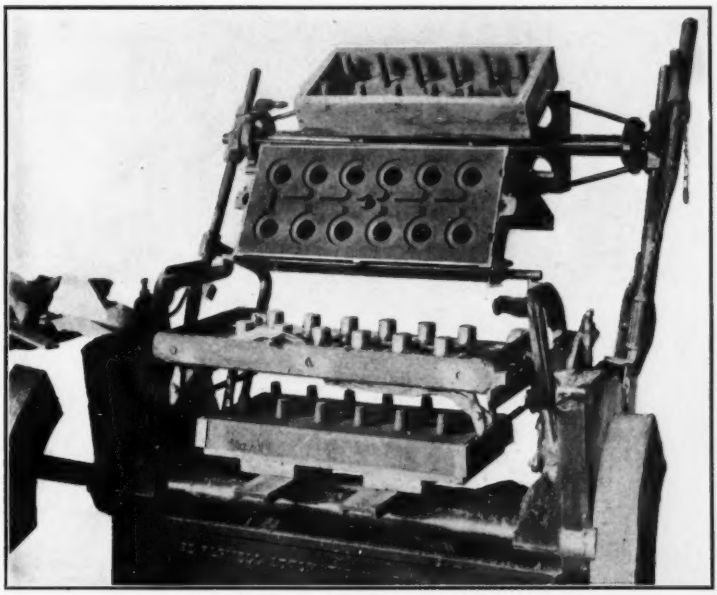
Installed by Heyl & Patterson, Pittsburg, Pa. The purpose of the plant is to provide a continuous moulding system, the moulds being conveyed from the moulding machines to cupolas where they are poured, and thence, cooling as they go, to a point where they are shaken out. Here the sand is automatically dumped, tempered, screened, and returned by a conveyor to the moulding machines for re-use. This view shows the shake-out end.



DINGS MAGNETIC SEPARATOR FOR FOUNDRY USE.

The lower view, taken in the Allis-Chalmers South Foundry, shows the feeding end. The machine is used for recovering iron from cinder-mill droppings, rattle-mill droppings, gangway scrapings, chipping-iron refuse, etc. It takes the material as fast as a man will ordinarily shovel it in. The upper view, from the foundry of Wm. Bayley & Sons, Milwaukee, shows the delivery end.

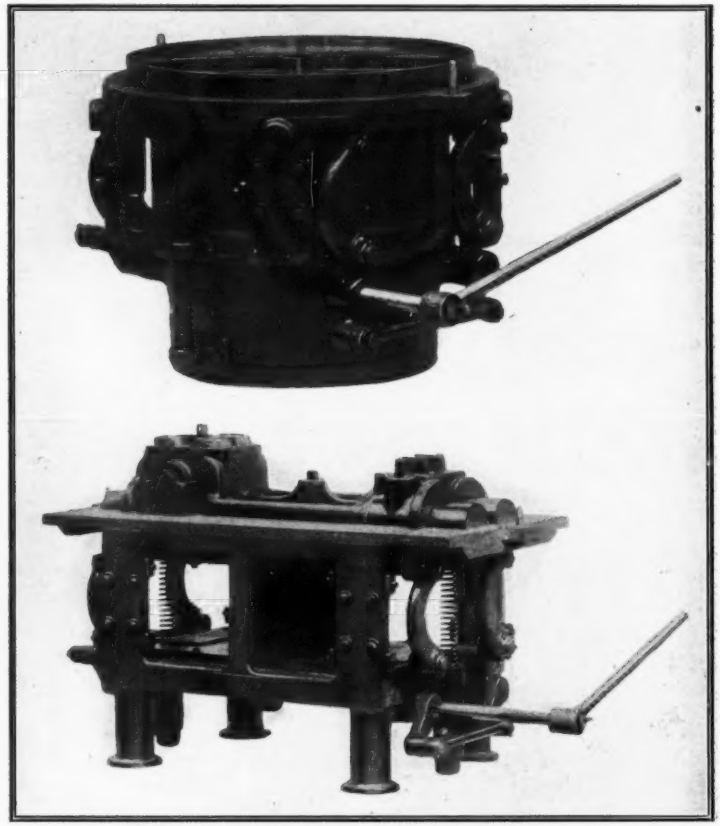
be effectively extended by the introduction of a magnetic separator just after the hot sand drops through the grating, and before it goes into the sifter. In fact, it is a question whether the introduction of a pair of rolls after the magnetic separator is not an improvement, as this does away with all subsequent manipulation of the lumps of baked moulding sand. The burnt and worthless sand goes away, attached to the castings, and is rolled off in another operation. The larger core parts might bother the system, and spoil the sand; but these can be caught on the grating and slid away.



FARWELL AUTOMATIC MOULDING MACHINE.
The Adams Co., Dubuque, Iowa.

The electromagnetic separator is a money-maker in any foundry. In all cases coming under my observation, they have paid for themselves three months after installation, the only necessity being to use the recovered shot properly in the mixture. Some day we may see the old dump heaps of foundries—at least in the Western United States—gone over by Chinamen with such a machine, and great will be the saving.

Now we come to the moulder, and the labor-saving devices with which he may increase his output effectively. Pounding sand is about

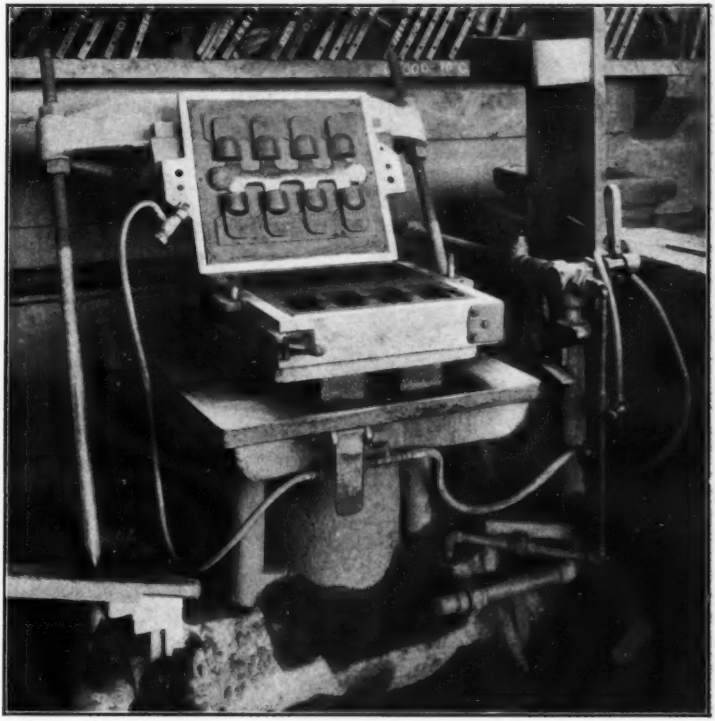


PRIDMORE ROUND AND SQUARE DOUBLE-SHAFT MOULDING MACHINES.

the most laborious work in any industry. At the end of the day, a moulder who has done his full duty is more fagged out than the navvy digging sewers. It requires muscles of steel to keep up the pace, as well as agility and precision. Every move must be made to count where intricate work is made in quantity. Very few moulders really work with method, and hence they make their occupation more laborious than it should be.

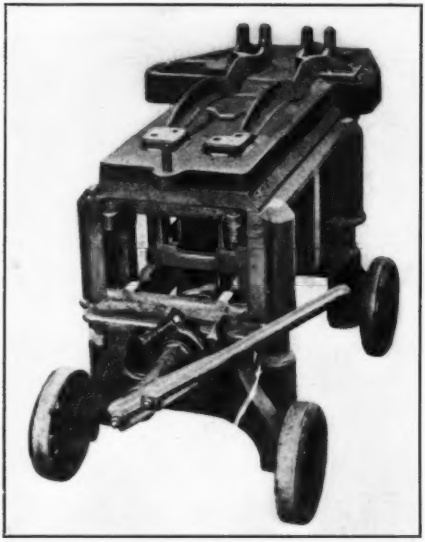
The pneumatic sand rammer is intended to relieve the moulder of much of this back-breaking work. Both the hand rammer and the portable machine for heavier work are very efficient, compressing the moulding sand evenly and uniformly at the rate of two hundred

blows and more per minute. The importance of this device is seen in shops where much heavy work is done. It sometimes happens that several men spend a week or more moulding up one piece in the floor, probably nine-tenths of the time being spent in pounding the sand. A couple of these pneumatic rammers can easily cut this time in half. The result is the doubling of the output for the shop, so far as that class of work is concerned. Yet how very few of these rammers do we see in use in foundries. Wherever they do go in, however, they are bound to stay. Again, in repetition work this rammer is very useful; where (for instance) a casting similar to a journal box for car work is made by the hundreds daily, the simple pounding



VIBRATOR FRAME MOULDING MACHINE, BRASS FOUNDRY OF GENERAL ELECTRIC CO., SCHENECTADY.

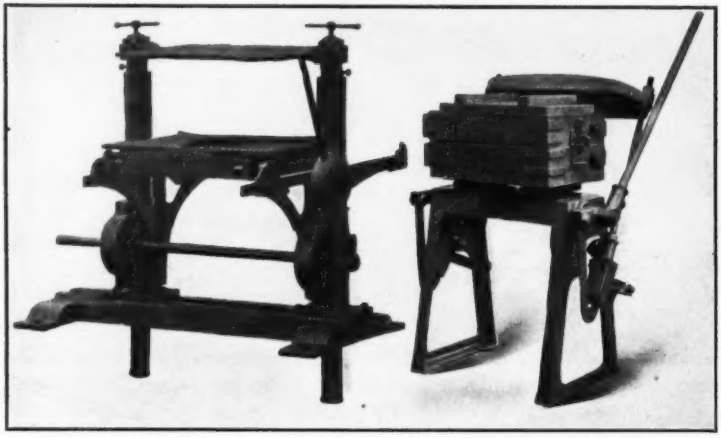
Patterns are machine-moulded by attachment to wooden boards boiled 10 hours in paraffine. These boards are then fastened in the detached vibrator frame of the machine and moulded as shown. Tabor Mfg. Co., Philadelphia.



PORTABLE MOULDING MACHINE.
Arranged with mechanism which keeps stripping-plate patterns constantly up to their proper height.
Tabor Mfg. Co., Philadelphia.

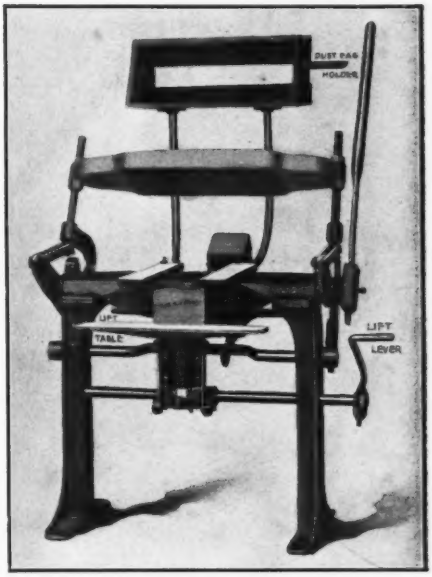
of the sand can be done much more quickly than by hand, and with just as much judgment.

The next step brings us to the moulding machine, than which no device has been more epoch-making in the foundry. From the simple "squeezer," or hand press, to the most complicated universal machine, which is made to perform successively each separate step in the cycle of mould-making on a number of moulds arranged on a revolving table, we have any number of mechanical constructions. Each machine is a money maker when used on the class of work for which it is specially adapted, but a disappointment when applied to any other.



HAND PRESS MOULDING MACHINES, MANUFACTURED BY SAMUELSON & CO., LTD., BANBURY, ENGLAND.

To see a moulding machine, with its complement of men, turning out one thousand three hundred moulds in ten hours where formerly the same pattern was good for only one hundred and fifty, must show the enormous capabilities of this labor-saving device, when judiciously applied. With a net gain of only 50 per cent. over hand work, any intelligent business man would be expected to jump at the chance of installing these machines. The introduction, however, has been most slow, both on account of the labor opposition, and the mistakes of application made by the pioneers in the business, now happily more successfully avoided.



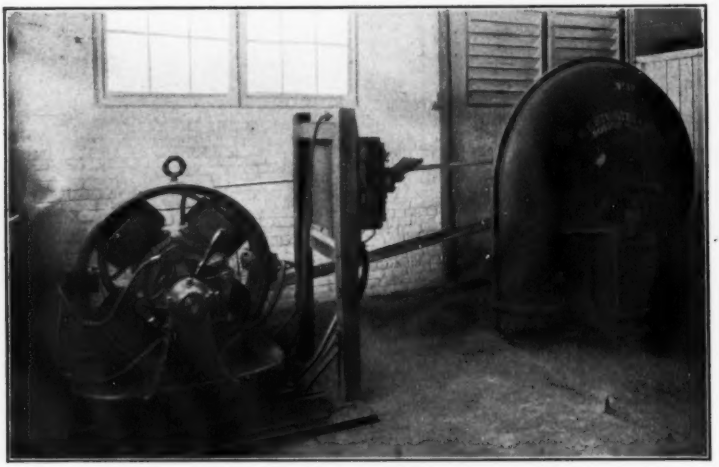
FARWELL UNIVERSAL MOULDING MACHINE.

May be used as combined moulding press and stripping-plate machine, as combined moulding press and flask lifter, without stripping plate, or as a plain moulding press. The Adams Co., Dubuque, Ia.

It would carry us too far to go into details along the lines of moulding-machine construction. Suffice it to say that these machines are made to run by hand, pneumatic, and hydraulic power. They may be provided with stripping plates to hold the sand properly from falling when the pattern is drawn, or they may use the vibratory rapping which gently disengages the sand from the pattern while it is drawn without the aid of the stripping plate. They may have the mould made and taken away in various ways. They may be fully or only partially automatic. The moulds may be made singly in iron flasks, or in snap-flasks which leave the blocks of sand free for subsequent manipulation before pouring. Or these blocks of sand may be ranged together in large floors showing only the pouring gates. Then come the special machines for moulding gear wheels, curved pipe, etc., and latterly much large dimension work, formerly thought impossible to make otherwise than by hand.

Five years ago this could not have been written, and even now we are in the transition period in this respect, the pressure of competition gradually forcing the owner to adopt, and the workingman to yield his opposition to, these most useful machines; if he does not, he must go under.

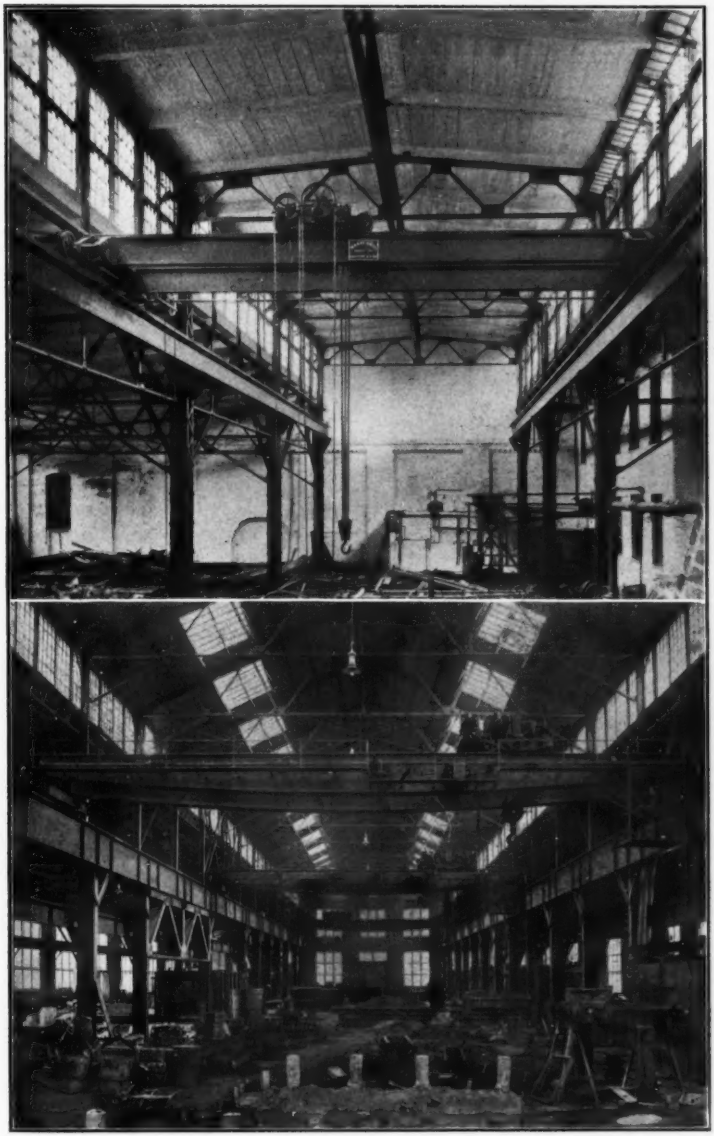
On the question of fans and blowers for the air-supply of the cupola little can be said. The devices in use are very efficient, and as engineering talent is becoming more and more available in the foundry, old notions on the transmission question are yielding somewhat to the necessities of power centralization and the benefits of a sufficient reservoir space in the blast pipe.



MOTOR-DRIVEN CUPOLA BLOWER OUTFIT, B. F. STURTEVANT CO., HYDE PARK FOUNDRY.

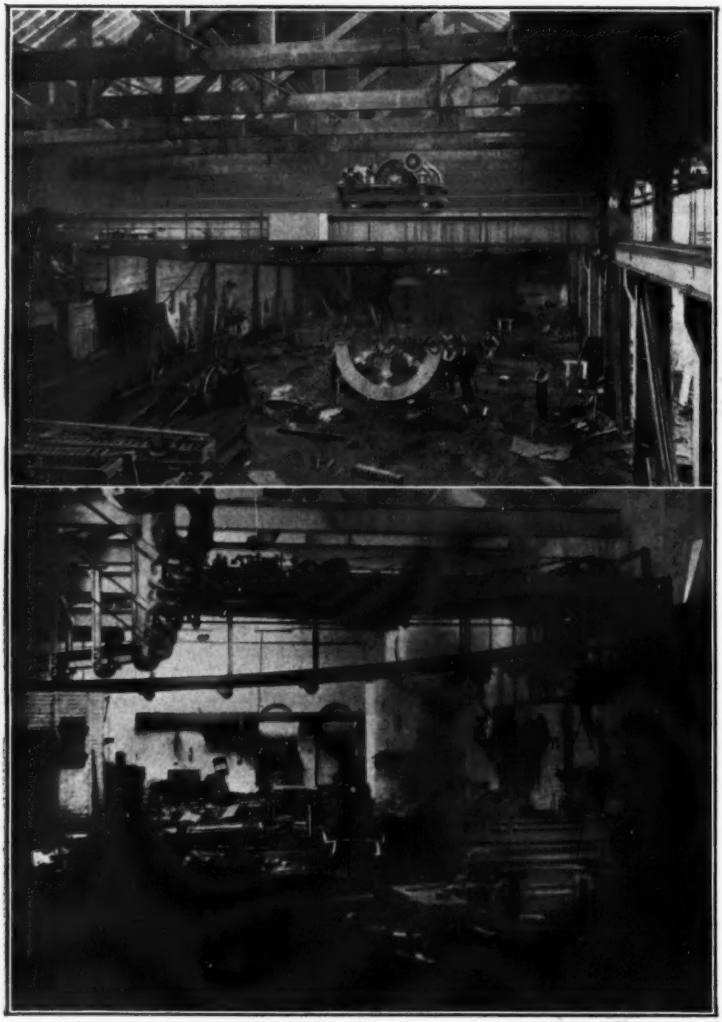
Among the least noticed, but most effective, labor-saving devices are the little things which go far to save time and work on the moulding floor. These are the shop rigs and tools, so-called, and are usually the creation of the foreman in charge, being adapted to the special needs of the patterns in hand at the time. Thus we have iron flasks shaped to hold the minimum amount of sand for the job, and yet so arranged that in closing up or turning over if required, nothing can go amiss. The variety of lifting tackle for transporting copes, handling heavy castings, and the like, is quite astonishing, as one can see after going through foundry after foundry.

Foundrymen will do well to send out their foremen and superintendents once in a while on a tour of inspection, and to conventions



CRANE SERVICE FOR THE FOUNDRY. OVERHEAD TRAVELING CRANES.

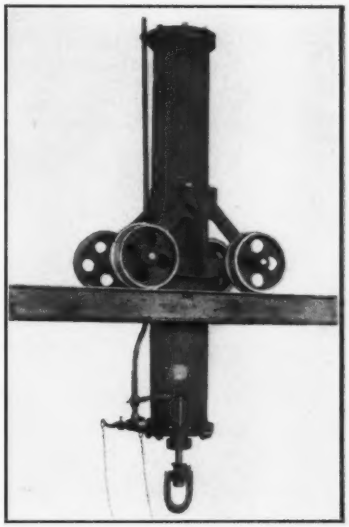
Above is shown a 27-foot span 20-foot lift 5-ton capacity crane installed by Maris Brothers, Philadelphia, for the Phosphor-Bronze Smelting Co. Below is the crane equipment in the chilled-roll foundry of the United Engineering & Foundry Co., Pittsburg, built by the Shaw Electric Crane Co., Muskegon, Mich.



CRANE SERVICE FOR THE FOUNDRY.

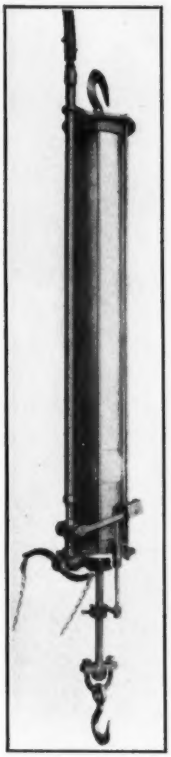
Above is a 30-ton four-motor overhead travelling crane of 55-feet span, with 5-ton auxiliary, built by Thomas Broadbent & Sons, Ltd., Huddersfield, for Fairbairn, Lawson, Combe, Barbour, Ltd., Belfast. Below is an 8-ton single-motor overhead crane of 22-feet span, built by the same firm for John Jardine, Nottingham.

of educational value. The bright man who is "right in it" himself will pick up many a pointer which more than repays the firm for the time and expense of his trip, not to speak of the friendly feeling created between establishments where such reciprocal visits are arranged for.



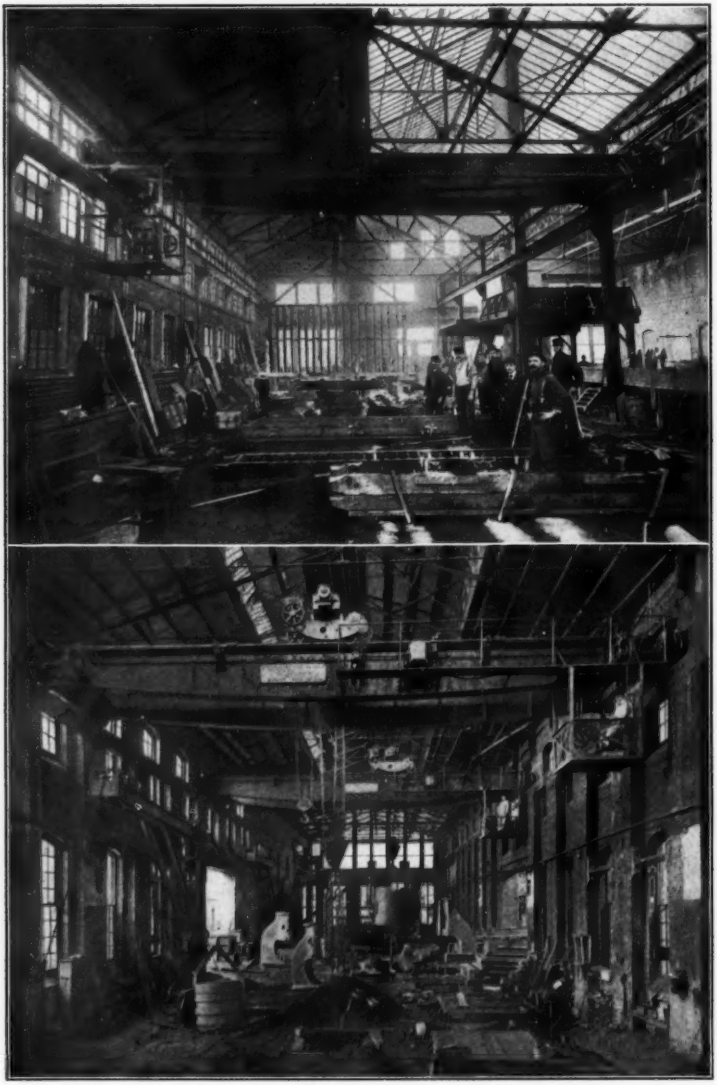
AIR HOIST WITH TROLLEY CARRIAGE.
Pedrick & Ayer Co.

A glance through the catalogues of the foundry-supply houses shows a steadily gaining list of appliances calculated to save labor. Snap flasks may now be gotten for many and variously shaped classes of work, and the pattern shop can also show a series of tools and specialties which cut down the hard and time-consuming labor very considerably.



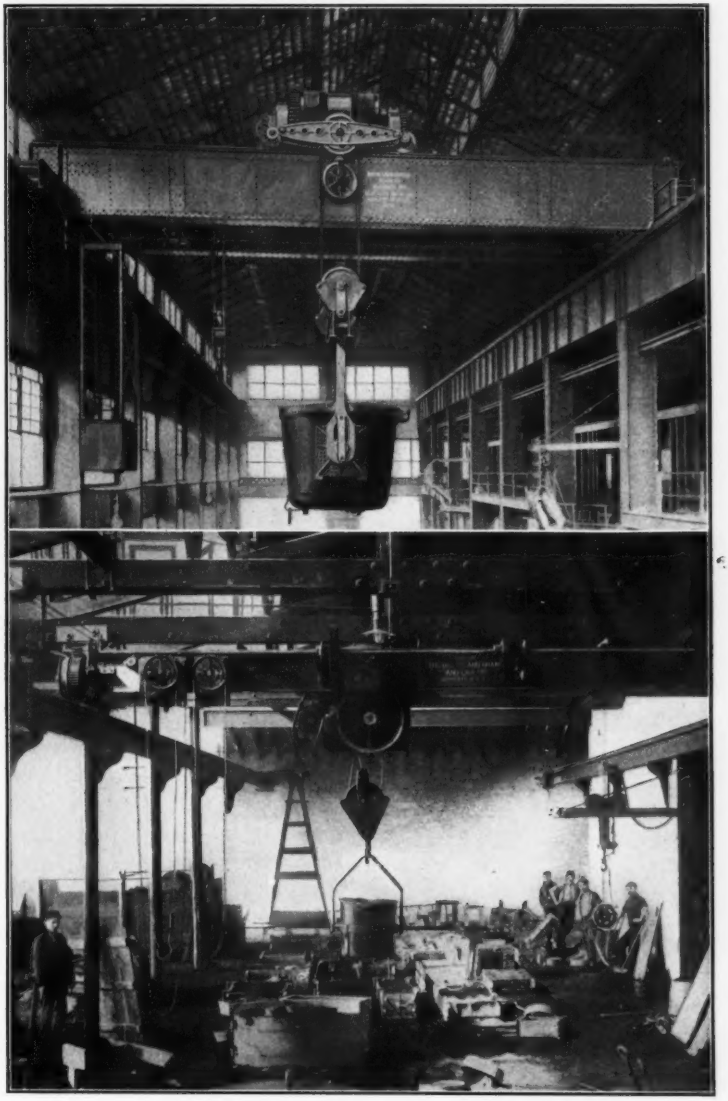
AIR HOIST.
Pedrick & Ayer Co.

Under the head of transportation in the foundry proper may be included the various types of cranes. The slow and cumbersome jib cranes, still seen very plentifully in slow and conservative foundries, are gradually being replaced by power cranes of whatever type the shop requirements make necessary. The tendency today in the new shops is in the direction of the electric traveling crane, which covers the entire floor space. Cranes run by other systems of power transmission also have their application, though the flexibility of the electric transmission system gives this the preference. Smaller jib cranes, when their use becomes desirable in connection with the travelers, are either located along the side walls, or are of the portable type, taken from column to column where wanted, and there hung in position. In the older remodeled



CRANE SERVICE FOR THE FOUNDRY.

Above is shown a 5-ton three-motor electric traveling crane built by the Cleveland Crane & Car Co. for the W. S. Tyler Company, Cleveland. Below is a 25-ton 48-foot span crane with 5-ton auxiliary hoist, built by the Niles-Bement-Pond Co. for the steam-hammer department of Bement, Miles & Co., Philadelphia.



CRANE SERVICE FOR THE FOUNDRY. OVERHEAD CARRIAGE OF MELTED METAL.

Above is a 75-ton ladle crane, with 25-ton auxiliary trolley, installed by Pawling & Harnischfeger in the open-hearth steel foundry of the Grand Crossing Tack Co. Below is a 10-ton two-motor crane for small overhead clearance, built for the Erie Engine Works by the Cleveland Crane and Car Co.

FIVE-TON TRAVELING WALL CRANE, FOUNDRY OF THE ALLIS-CHALMERS CO., WEST ALLIS, WIS.

Being on a separate run-way from the standard overhead traveler, this type permits independent auxiliary service. By Pawling & Harnischfeger, Milwaukee.

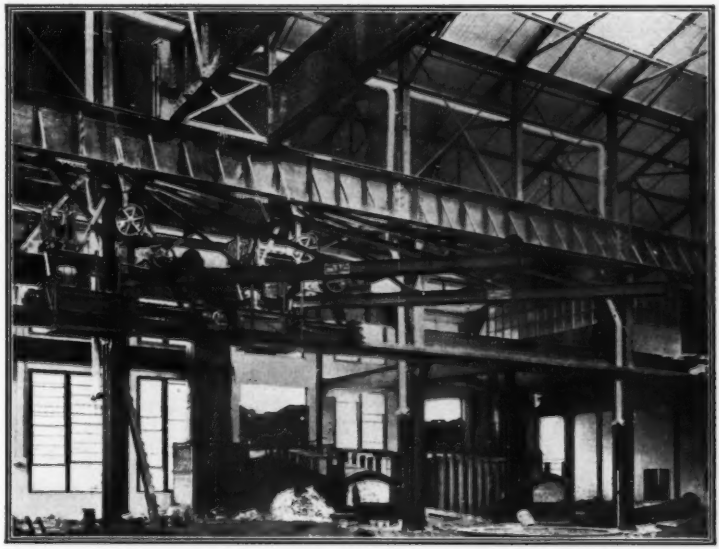
foundries, where the structural work for the crane run-ways cannot be put up, powerful steam-actuated jib cranes are advantageous, though requiring somewhat of a localization of the heavier work about them.

As the cranes are required to handle everything about the foundry, from carrying in the sand to taking out the castings, it will be seen that a very busy place will require two travelers, each supplied with two hoisting bridges. Thus four hooks are available at one time, if wanted, and the getting out of work is facilitated wonderfully. On all crane systems there can be attached a pneumatic hoist wherever a quick and yet even lift is wanted. These air hoists are very handy, and are now much seen in shops where moulds are carried overhead, instead of the iron being carried to fill them.

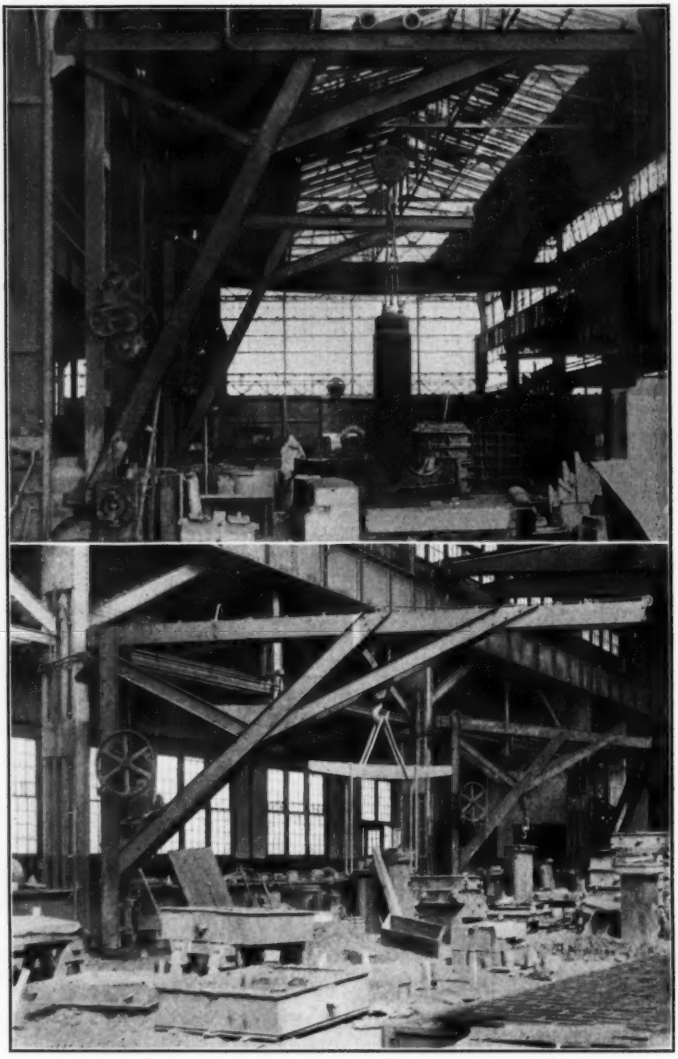
The ideal method of carrying melted metal is from overhead. Occasionally, however, it is necessary to supplement the traveler with a track system by means of which buggies, filled with the metal, can be taken out of the shop into additions not covered by the crane system. Then again the cupolas may not be within reach of the crane,

and the iron must first be brought within its range. Where the installation of a traveling crane is not possible, or in fact where the work is light and the floors cover much space, the overhead-track system is highly advantageous, the men taking off the iron from the cupola spout in suspended ladles holding four or five times the amount four men could carry in shanks. Systems of this kind have proved great labor savers.

Should we wander through the core room we would occasionally find a new device for automatically clamping the core boxes together for filling, thus doubling the output of the operative. Specially constructed drying plates for intricate cores reduce their loss, and the losses incurred through castings which have to be scrapped. Well designed ovens allow a continuous replacing of the baked material by fresh lots, without interfering with the process in the least. Only on the question of core machines for green sand and regulation cores of more intricate construction have we nothing satisfactory in the market. Here is a chance for the inventor with foundry knowledge, for the countless varieties of castings which could be reduced in cost by a moulding machine making green-sand cores ready to drop into

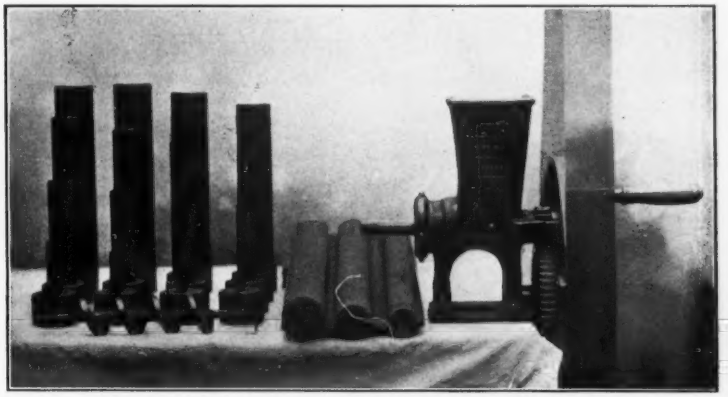


TRAVELING JIB CRANES, TRAFFORD CITY FOUNDRIES OF THE WESTINGHOUSE.
Wm. Sellers & Co., Philadelphia.



CRANE SERVICE FOR THE FOUNDRY. AUXILIARY AND JIB CRANES.

Above is an electric auxiliary jib crane, transferable type for light work, installed by the Northern Engineering Works of Detroit in the works of the Buffalo Foundry Co. Below is a crane of similar type, by Alfred Box & Co., Philadelphia, in the new foundry of the General Electric Co., Schenectady, N. Y.

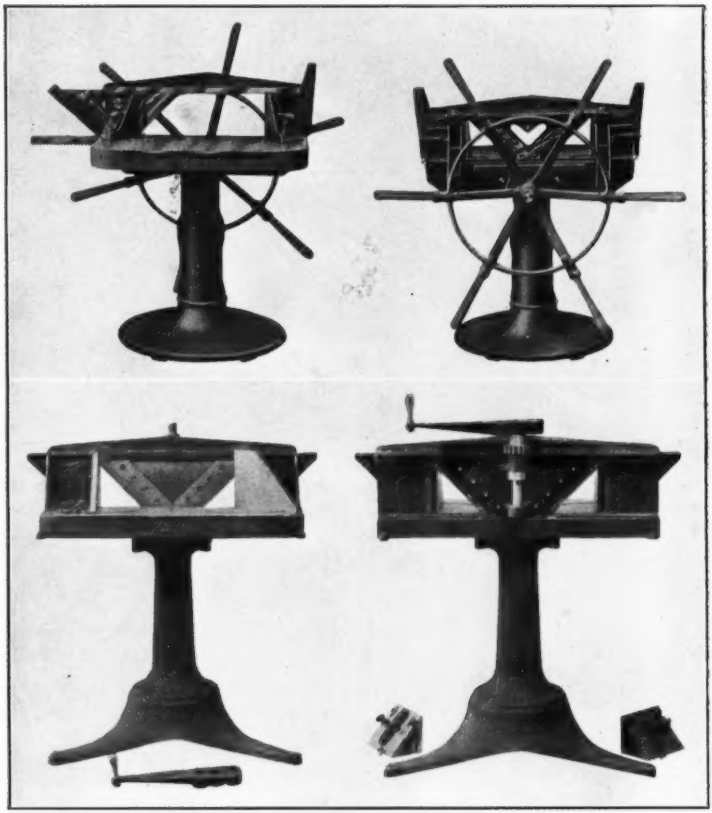


CORE MACHINE, FOR ROUND, HEXAGON, OR OVAL CORES, VENTED.
Railway Speed Recorder Co., Kent, Ohio.

their moulds, and thus replace the expensive baked article, would make such a machine a rapid seller. For the so-called stock cores which are now to be found in every foundry doing a jobbing business, machines are now on the market making a far better grade than ever came from hand work, and they turn out any diameter and length, properly vented. These stock cores are a great labor-saving institution, as a pattern maker need no longer be called in to make a lot of core boxes of various sizes for a casting, the blue print of which shows that a series of bolt holes are to be cored out. The moulder simply breaks off enough of the stock core to insert into the space left by the prints on the pattern, and the matter ends there.

In the subsequent handling of the castings, after leaving the sand, we run across a variety of labor-saving appliances. In large foundries, especially those producing brass and bronze castings, we find gate cutters, and even band saws for cutting off the runners and sprues. The steel foundry goes even further and utilizes the cold saw for this work, formerly so very laborious when handled with hammer and chisel. For taking off fins and irregularities on the face of a casting the pneumatic chipping tool is doing wonders in the way of quick work. The emery wheel also is now applied not only to stationary grinding work, but by means of the flexible shaft it may be carried about the trimming room for touching up surfaces where needed.

Taken all in all, the foundry has but few problems which have not been studied with a view of replacing hand work by labor-saving



OLIVER WOOD TRIMMERS, FOR THE FOUNDRY PATTERN SHOP.
Manufactured by the American Machinery Co., Grand Rapids, Mich.

devices. Yet in few foundries do we see many of them applied. In a manufacturing establishment the foundry is usually voted a necessary evil, and oftentimes we hear the accountants declare that the plant could buy the castings cheaper outside, were it not for the difficulty of getting prompt deliveries. When considered from the standpoint of the "union" shop, with the "shop committee" in cahoots with the foreman, or terrorizing him; the superintendent knowing very little of the art of making castings; the moulders putting up their self-constituted day's work by two o'clock in the afternoon, and loafing about thereafter—the opinion above expressed is certainly correct.

THE DEVELOPEMENT OF POWER-DRIVEN MACHINERY IN THE MINE.

By E. H. Roberton.

The mine is of particular interest in relation to labour-saving methods, because it was the cradle of the steam engine. Indeed, some of the early inventors seem to have thought of no use for steam power except in the pumping of mines. Now the range of useful and economical mining machinery is so vast that only its outline can be sketched and typical examples illustrated. Mr. Roberton gives a condensed survey of the field and the principal directions of progress in the use of power machines in mining.—THE EDITORS.

NEWCOMEN WINDING ENGINE, FARME COLLIERY, RUTHERGLEN. ERECTED 1810; STILL WORKING.

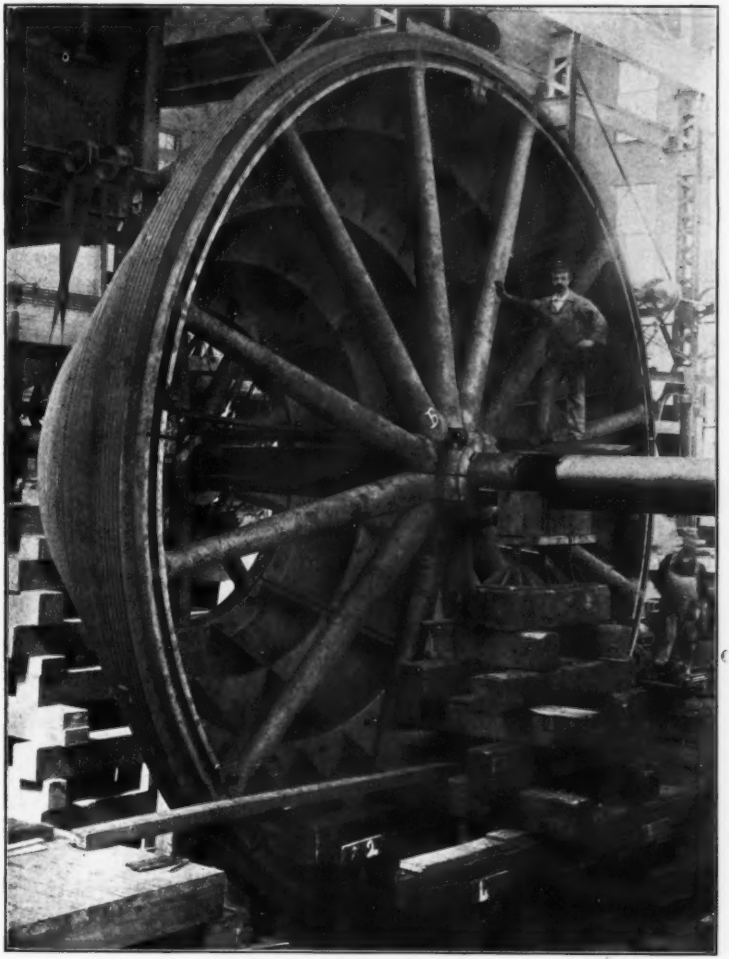
TO the mining engineer, the study of the developement of mining machinery and its influence on the conditions of the mine worker has been always full of absorbing interest. To look back on the days when our predecessors worked often in total darkness, and in daily hazard of their lives, is to admire the untiring ingenuity with which the difficulties then experienced have been one by one surmounted and left behind. The mineral was entirely worked by hand, the pick and wedge being the principal tools used; sledges were used to convey the loaded baskets to the shaft, for rails were not then thought of; the mineral was carried up the shaft by means of ladders or perhaps a hand winch, or later by a horse whim or gin; ventilation was entirely neglected, with the result that only a very few acres could be worked from one shaft, owing to the foul and stagnant air existing in the workings. Such were the conditions under which the operations connected with the extraction of mineral from the earth were laboriously carried out, before the introduction of mechanical power into the various details of mining was attempted.

The attention of the mining engineer was first turned towards labour-saving machinery by the necessity of finding a solution of the water difficulty. In earlier days pumping was eliminated as much as

GIRL "HURRYING" COAL WITH STRAP AND CHAIN.
From the report of the Royal Commission, 1842.

possible by the use of natural drainage, a tunnel or adit being driven from the hill-side into the workings to enable the water to run out into the valley. This method was used for centuries, until at length the exhaustion of the surface deposits made the need felt for some means of draining workings that penetrated below the lowest level of the valley. Various devices were used, such as winding the water in buckets, or pumping by horse or water power, but these apparently only staved off the evil day. This point is the landmark in the history of mining at which steam appears, the first practical steam pumping engine being Savery's, invented in the year 1698. A small working model of this engine was shewn before the Royal Society on June 14, 1699, by Captain Savery, who called it the "Miner's Friend." Its action was precisely similar to that of the modern pulsometer, excepting that the valves were worked by hand. The pump consisted of two compartments alternately filled with water by suction, and emptied by the pressure of steam acting directly on the surface of the water, and was said to be capable of raising water two feet for every pound pressure in the boiler. This and

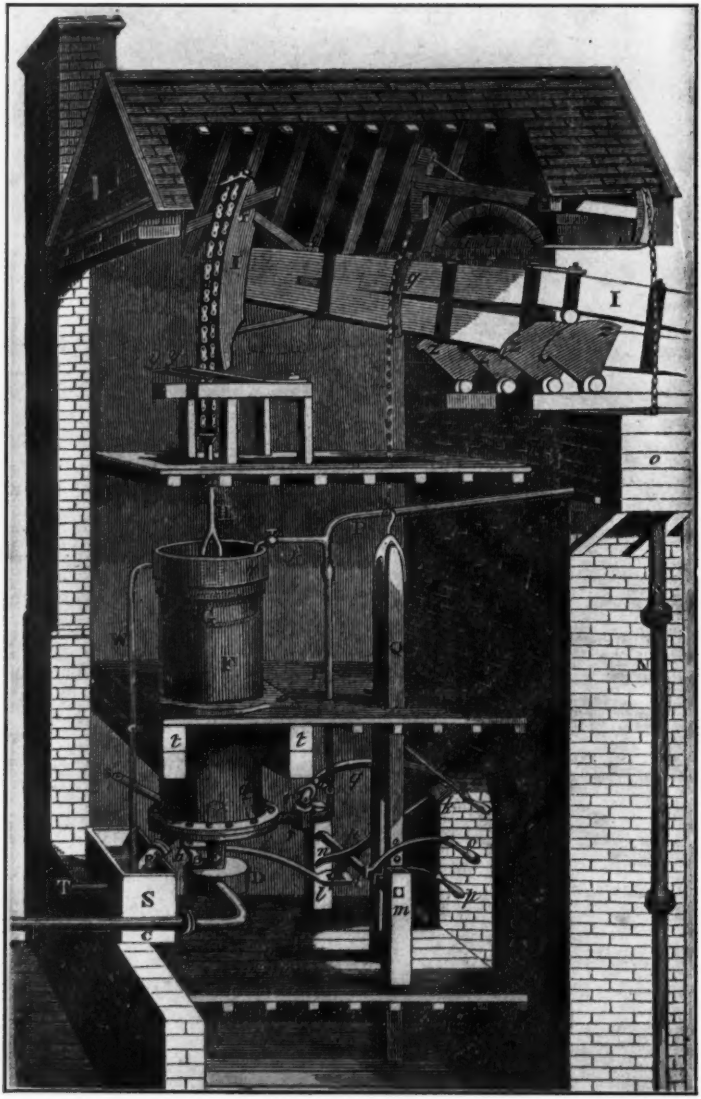
COLLIERY WINDING ENGINE, COALBROOKDALE, MADE ABOUT 1790.
From Mr. Henry Davey's paper before the Institution of Mechanical Engineers.



HALF OF A MODERN CONICAL WINDING DRUM, SHOWING THE INTERIOR FLANGES. Size 25 feet 5 inches by 12 feet. Built by the Allis-Chalmers Company for the Atlantic Mining Company.

some other early forms of the steam engine are shown on the following pages.

The first piston engine to be used was built by Newcomen and Cawley, and worked at a mine near Wolverhampton. Improvements

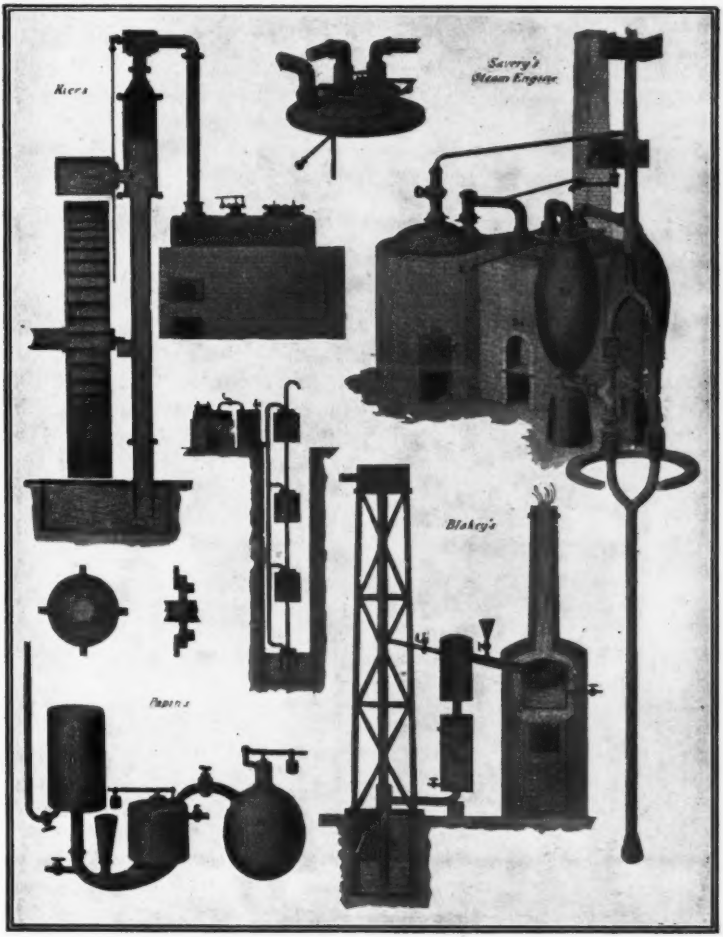


THE NEWCOMEN PUMPING ENGINE. FROM GALLOWAY'S "HISTORY AND PROGRESS OF THE STEAM ENGINE," 1827.

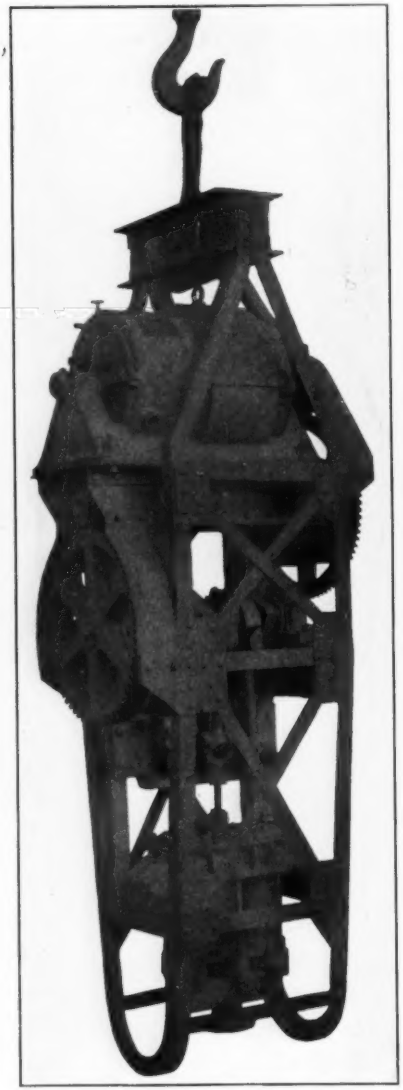
This represents the "atmospheric" engine as improved by Smeaton, and shows the advance which had been made along this line at about the time Watt was engaged on his independent investigations.

in this type of engine were introduced by Smeaton, Watts, and Woolf. Thus was evolved the Cornish pumping engine, which is still in great favour with mining engineers, being especially useful where there is an excessive quantity of water to be dealt with.

Since the introduction of the Cornish engine there have been many newer types of pumping engine placed on the market, devised mainly



SOME OF THE EARLIEST FORMS OF THE STEAM ENGINE APPLIED TO MINING.

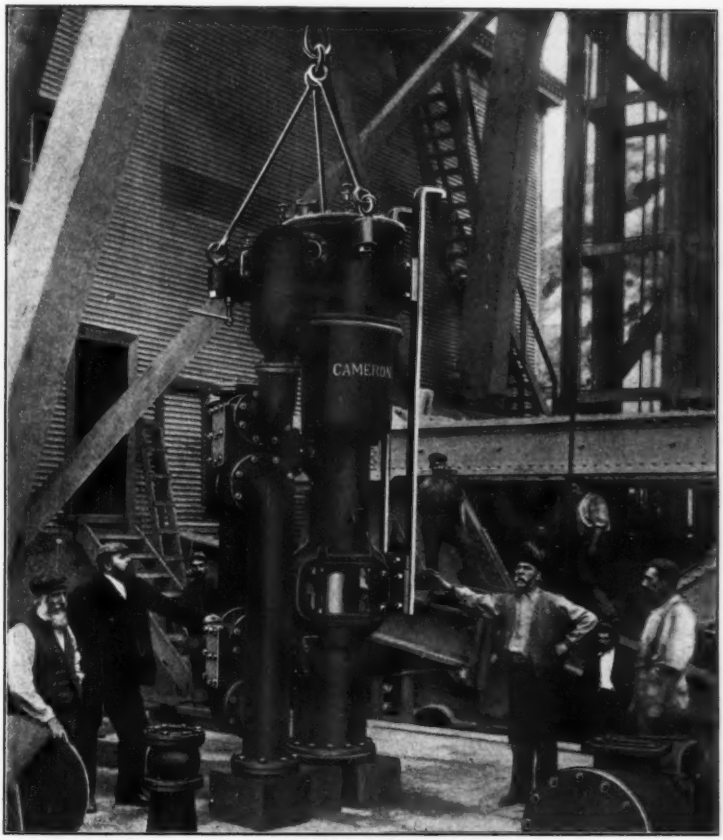


ELECTRICALLY DRIVEN SINKING PUMP.
Easton, Anderson & Coolden, Ltd.

with a view to greater working economy, or designed for some special purpose. For instance, in the operation of sinking, large feeders of water are often met with, and as this is often very gritty, special forms of pumps have been devised to raise it to the surface. These are designed with a view to great portability, and suitability for working suspended in a confined space, and also for the discharge of a large quantity of water relatively to the size of the pump.

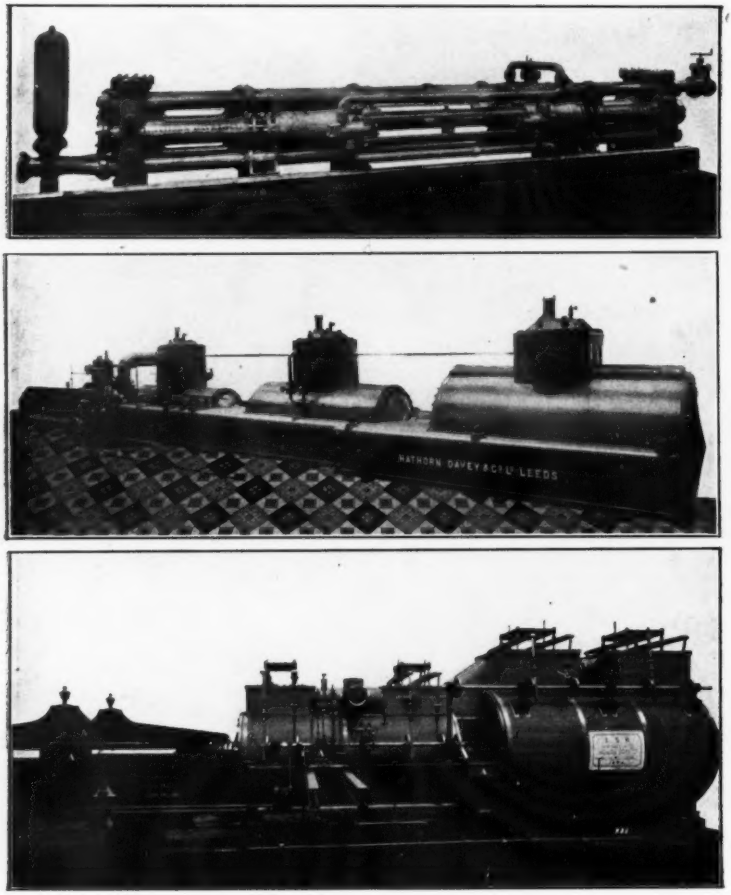
In the case of a mine which does not give out an excessive amount of water, that type of pump is preferable which is situated at the bottom of the shaft and derives its power from steam led down the shaft. Electricity can be used, and in many mines this is the power transmitted, but for large pumps steam is preferable unless the use of steam pipes is undesirable owing to the position of the pumps.

It is probable however that for raising the water from sinking shafts electricity will supersede steam, owing to its eminent adaptability for the rapid raising and lowering of the pump, without the disadvantage of leakage of power through defective



CAMERON VERTICAL SINKING PUMPS FOR THAMES HAURAKI GOLDFIELDS, LTD., NEW ZEALAND. CAPACITY, 1,500,000 GALLONS A DAY.

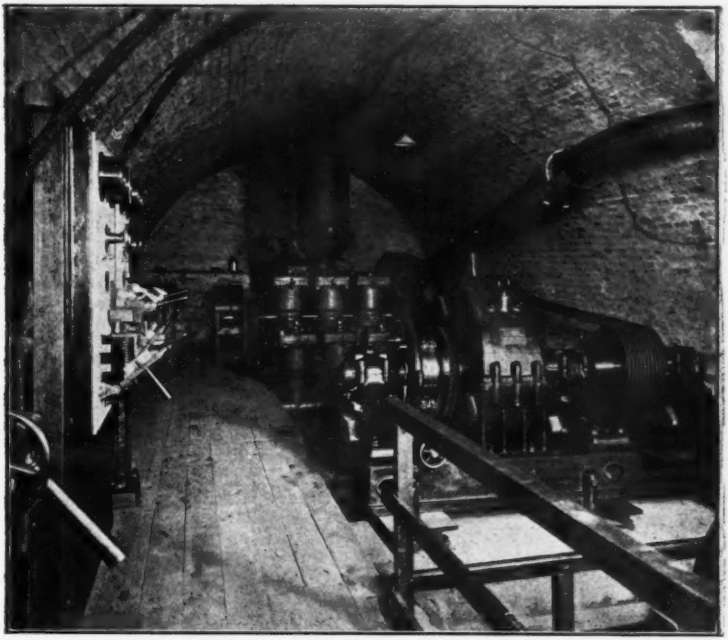
steam joints. For working pumps, too, near the face, and at a distance from the shaft, electricity is admirably suited. It has always been a costly process to keep the working faces dry when working to the dip. In flat and slightly undulating strata especially, the water collecting in the working face is a constant source of annoyance both to the mining engineer and to the working miner himself. The usual method of overcoming this difficulty has been either by the use of hand pumps, or pumps worked by a crank connected with the mechanical haulage. Electrically driven pumps, owing to their extreme portability, afford an



TYPES OF MINE PUMPING ENGINES.

At the top is a hydraulic pump for Loamhead Colliery, capable of forcing 300 gallons a minute from a depth of 1,000 feet. Next is a triple-expansion differential pumping engine for main-shaft pumping, 27, 40, and 66-inch cylinders, 8-feet stroke, 34-inch pumps. At the bottom is a compound differential pumping engine, South Staffordshire mine-drainage type, capable of raising 1,500 gallons a minute from a depth of 900 feet. Cylinders 45 and 76 inches, 10-feet stroke, 24-inch pumps. All are by Hathorn, Davey & Co., Ltd., Leeds.

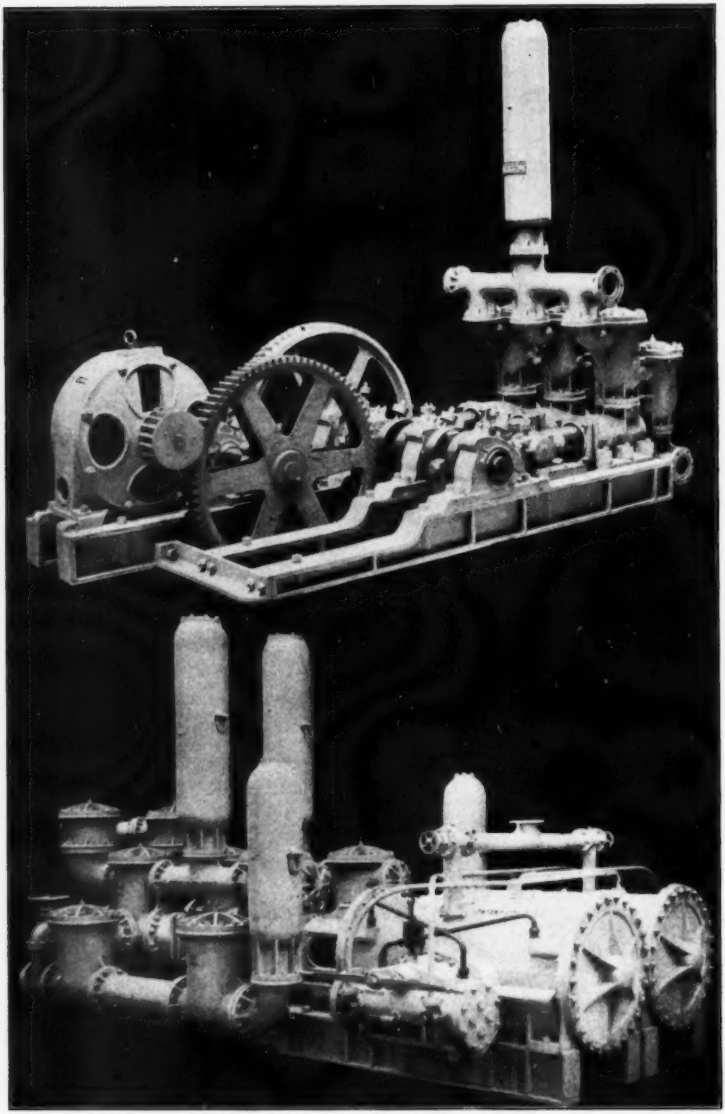
excellent solution of this problem. Occasionally hydraulic, compressed-air, or oil-engine pumps are used; the last named being as a rule unsuitable, since coal dust enters with the air into the carburettor and causes trouble.



ELECTRICALLY DRIVEN UNDERGROUND PUMP, SOUTH DURHAM COLLIERY.

Two three-throw ram pumps, 11 inches diameter and 18 inches stroke, each designed to raise 500 gallons of water 400 feet at 28 revolutions; 95 amperes, 500 volts; by Ernest Scott & Mountain, Ltd.

As the depth of mines increases, the water difficulty, in so far at least as coal or other stratified mineral is concerned, will tend to diminish, as the water does not readily penetrate through the lower strata, and after the shafts have been tubbed and made watertight there will be little water to contend with. In such mines however as proceed to depth, making at the same time large quantities of water, the problem of economical deep-mine pumping must be faced. To place the engine at the shaft bottom is out of the question, as beside the danger of the engine room being "drowned out," the sectional thickness of metal required in a deep mine for the lower portion of



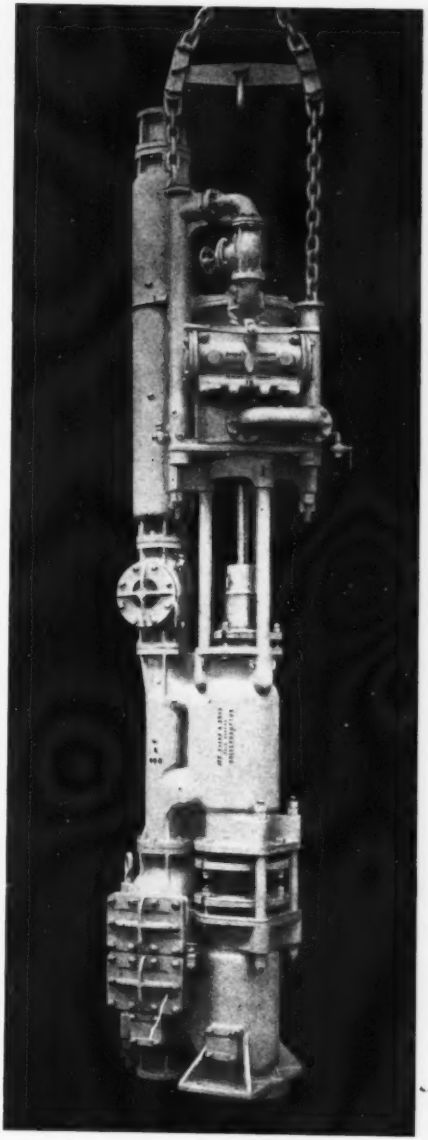
THE LOWER FIGURE IS AN "UNDERGROUND PUMPING ENGINE" AND THE UPPER FIGURE AN ELECTRICALLY DRIVEN THREE-THROW UNDERGROUND RAM PUMP.

Both by Jos. Evans & Sons, Wolverhampton.

the rising main would be excessive. On the other hand, spear rods of great length working in the shaft would prove very unwieldy, and be a possible source of weakness and danger. Probably a compromise between the two would serve best, the engine being placed in a chamber half-way down the shaft, pumping from the bottom to its own level by means of spear rods, and at the same time forcing the water from its own level to the surface.

If the miner of the present day were asked what he considered the greatest improvement in mine methods effected during the past century, he would probably point to artificial ventilation. The miner cannot perform good work where there is not good breathing air, and it is quite noticeable that in any district of a mine where for some reason or other the air becomes "slack," the output per man immediately diminishes.

In the early days of mining, in mines where ventilation was not entirely neglected, natural ventilation was deemed



EVANS SINKING PUMP.

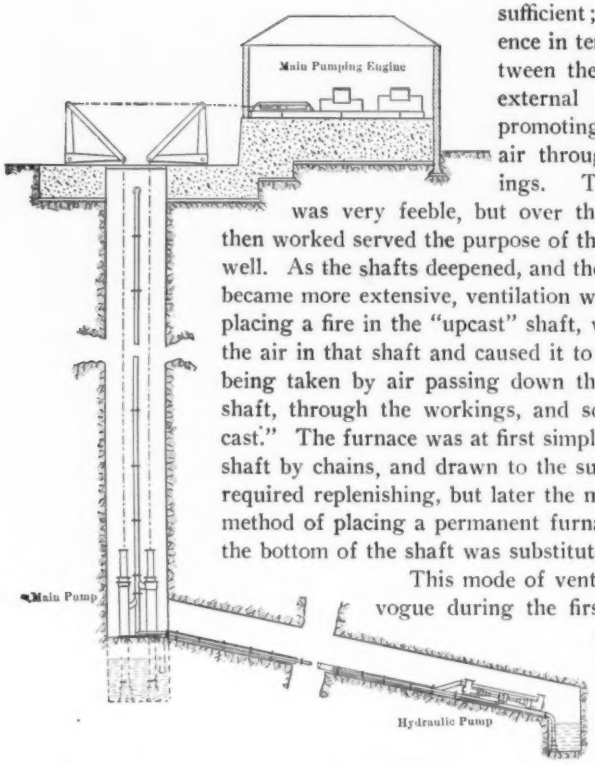
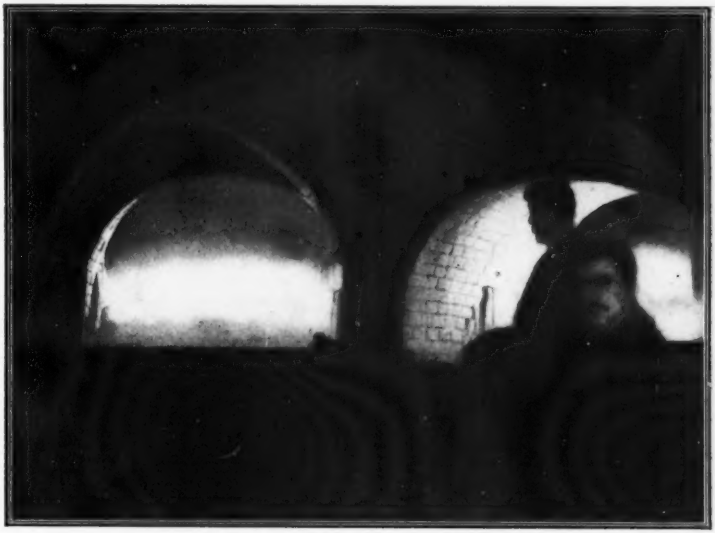


DIAGRAM SHOWING APPLICATION OF A HYDRAULIC PUMP TO DIP WORKINGS.
The pump is driven by water taken from the foot of the rising column of the main pumps.

sufficient; the difference in temperature between the internal and external atmosphere promoting a current of air through the workings. This of course was very feeble, but over the small areas then worked served the purpose of the miner fairly well. As the shafts deepened, and the area worked became more extensive, ventilation was effected by placing a fire in the "upcast" shaft, which rarefied the air in that shaft and caused it to rise, its place being taken by air passing down the "downcast" shaft, through the workings, and so to the "upcast." The furnace was at first simply slung in the shaft by chains, and drawn to the surface when it required replenishing, but later the more thorough method of placing a permanent furnace grating at the bottom of the shaft was substituted.

This mode of ventilation was in vogue during the first half of the past century, and even now is made use of in many important mines. At a large colliery in the north of England, a furnace utilised in a pit drawing over 1,000 tons per diem creates a ventilating current of 100,000 cubic feet per minute, with a water gauge of 0.6 inch.

The first attempt to construct machines for mechanical ventilation resulted in the production of reciprocating contrivances, being in fact huge air pumps. These, in order to produce anything like adequate ventilation, had to be made of enormous dimensions, and were proportionately clumsy. The excessive wear and tear of the reciprocating parts and of the valves soon caused this type to be discarded, the only one obtaining any success being the Hartz blower. A rotary displacement fan, known as Root's blower, attained some success in



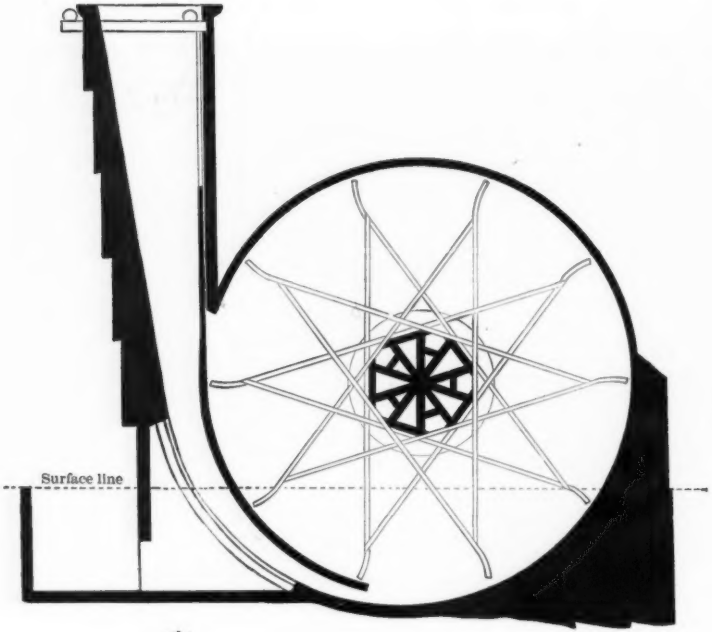
UNDERGROUND FURNACES FOR MINE VENTILATION.
Situated at a depth of 400 feet. Each furnace is 8 by 4 feet.

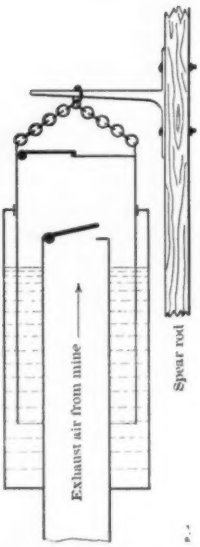
mine ventilation, but is now generally used for furnaces and smiths' fires. The type of fan which has superseded all others is the centrifugal type, and at the present day over 90 per cent of ventilating machines at work are of this type.

The consumption of air in a mine is roughly gauged by the number of men employed underground at one time, 500 cubic feet of air per minute being allowed for each man, and in the case of a gaseous pit, as many as 1,000 cubic feet per man per minute are needed. This excess is needed to dilate the harmful gases exuded from the coal, or generated by shot firing, and to supply air to the horses and ponies.

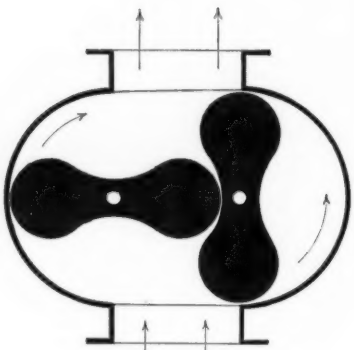
Some idea will be gained from this as to the enormous capacity and power of a modern ventilating fan, especially in view of the great lengths of galleries requiring ventilation, the friction caused by the tortuous passage of air through an extensively worked area, such as is now served by one pair of shafts, being a very considerable item.

Perhaps nothing has exercised more influence on the development of mining than the introduction of mechanical haulage. With its aid the mining engineer lays out, from one pair of shafts, workings over an extent that in the days of hand or horse haulage he would have declared impossible. So perfect is modern practice in this respect that



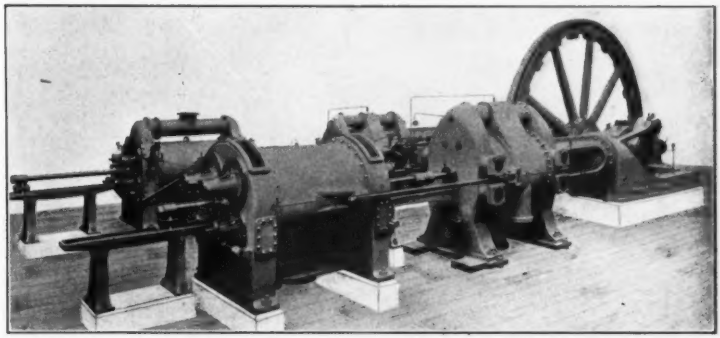


Hartz Blower



Root's Blower

MECHANICAL VENTILATING APPARATUS.
THE TOP FIGURE IS THE GUIBAL FAN.

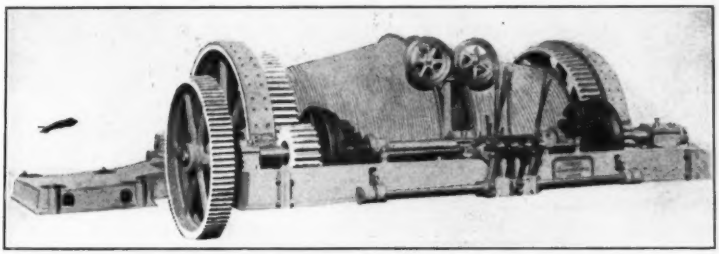


RIEDLER AIR COMPRESSOR, BUILT FOR SIMMER & JACK, EAST PROPRIETARY MINES, JOHANNESBURG.

Steam cylinders 34 and 56 inches, air cylinders 32 and 52 inches, stroke 60 inches; 8,040 cubic feet free air when running 58 revolutions; 120-pounds steam, 75-pounds air pressure; flywheel 26 feet diameter, 36 tons. Fraser & Chalmers, Ltd., London.

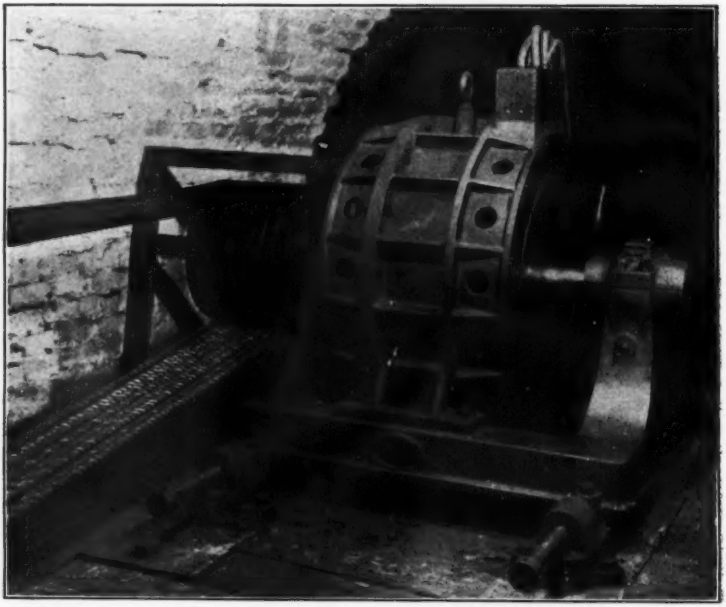
the cost of underground conveyance of material has been reduced to less than 2d. per ton per mile. The arduous labour of dragging the mineral in a sledge along the underground passages was replaced by hand haulage over wooden rails, which in turn gave way to horse-haulage over iron rails. And now over the greater part of the workings rope haulage has taken the place of hand and horse haulage, and with the introduction of electrical and compressed-air locomotives, mechanical haulage bids fair to supersede both men and animals in every large mine.

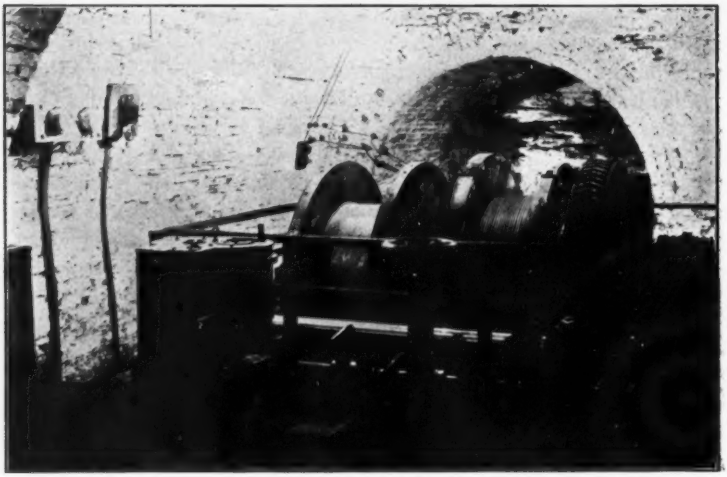
The earliest attempt at mechanical haulage was the simple contrivance by which a number of full tubs descending an incline were made to draw up a similar number of empty tubs. by means of a rope passing over a pulley at the top of the incline. The first introduction



ELECTRIC MINE HOIST WITH DOUBLE CONICAL DRUM.

Driven by 150-horse-power direct or alternating-current motor. Denver Engineering Works, Denver, Col.

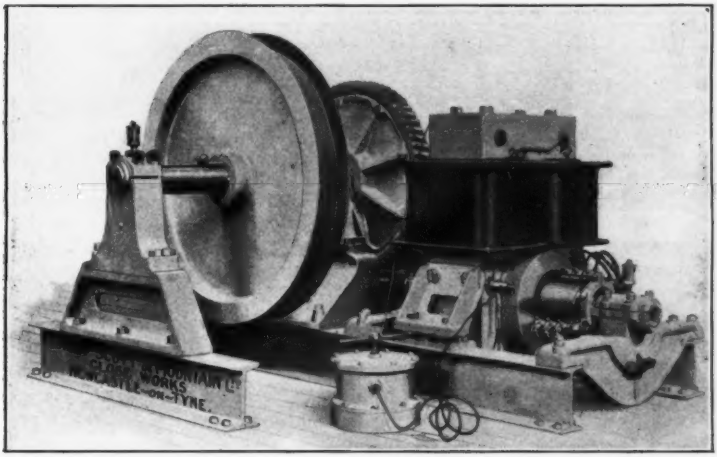




UNDERGROUND MAIN AND TAIL-ROPE ELECTRIC HAULAGE, TY TRYST COLLIERY.

50 horse-power, rope-driven from three-phase motor; speed 5 miles an hour up a gradient of 1 in 11; drums 5 feet in diameter and 2 feet wide. The upper figure shows the motor and driving end. Installed by Ernest Scott & Mountain at the Pochin Colliery of the Tredegar Iron and Coal Co., Ltd.

of power haulage was effected by an endless chain which passed in and out of the workings taking the tubs along with it. The chain soon gave way to the wire rope, which was found to be much lighter and more reliable, and is in great favour at the present day. Another very common mode of power haulage is known as main and tail-rope haulage, and consists of a "main" rope which draws a set of full tubs out of the workings, while a "tail" rope, of lighter make, attached to the end of the full set, passes round a pulley at the inbye end, and draws the empty set inbye, the empty set also pulling the other main rope in with it.



ENDLESS-ROPE HAULAGE, ELECTRICALLY DRIVEN THROUGH WORM GEAR.

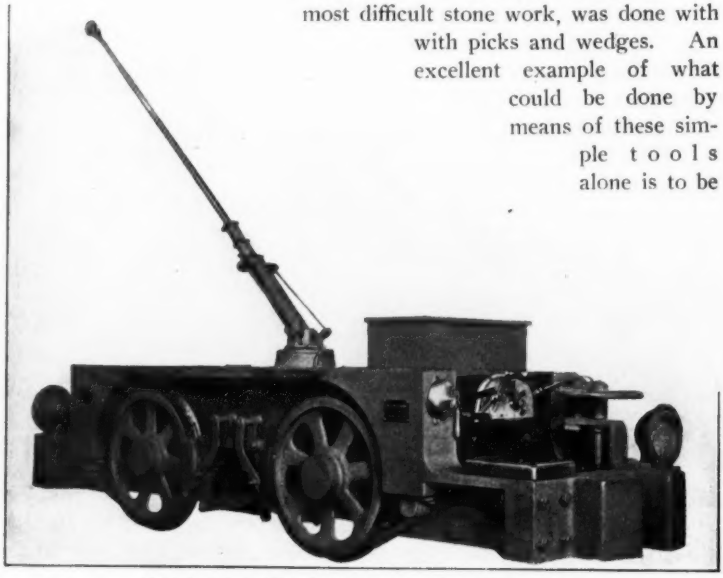
The best practice in secondary haulage is to be found in some American mines, where the replacing of animals by locomotives is said to have reduced the cost of underground haulage by over 50 per cent. The drawbacks to the use of locomotives in mines are the necessity for using heavier and more carefully laid rails at the face, and the difficulty of lifting the motor on to the track in the event of its becoming derailed. The choice of power lies exclusively between compressed air and electricity, steam and oil being rejected on account of the heat and fumes generated. Compressed-air motors are useful in their cooling effect, and in adding to the ventilation of the mine. If working in large and fairly straight galleries, which allow of a capacious receiver being used on the motor, a pressure of 500 pounds is used, but if the workings are narrow and permit only of a small

receiver being used, the pressure is often as high as 2,000 pounds. The useful effect of these motors is nearly doubled by heating the air before passing it into the cylinders.

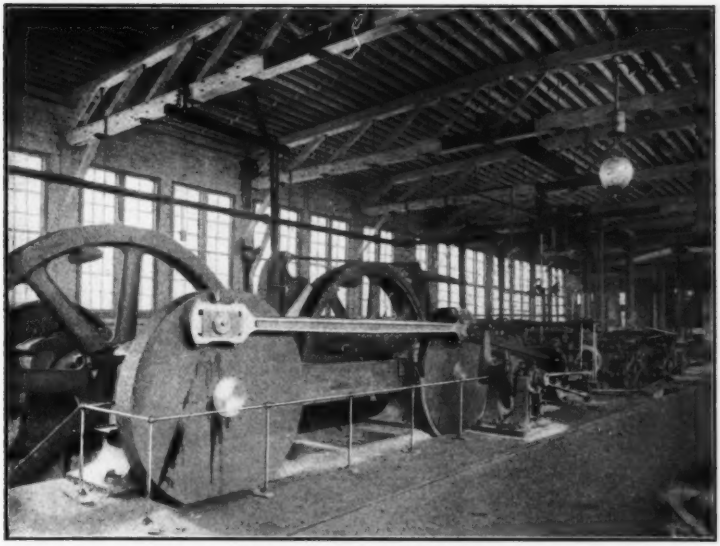
The electrical underground locomotive has been in use in America since 1889, and at the present day it is estimated there are about 700 at work. It has many advantages over the compressed-air motor, not the least being the simplicity of its construction and mode of operation. A comparison of electrical and compressed-air locomotives shews that for a given tractive power the former occupies a considerably smaller space, its length being four-fifths, and its cross section one-third that of the latter, while of course the distance over which the former can run is indefinite, the latter being limited to its air capacity.

It is probable that in the near future one of the chief factors that will make for the developement of our mining industries, especially of the coal industry, and for cheapening the cost of production, will prove to be the increasing use of labour-saving machinery in the actual working of the mineral.

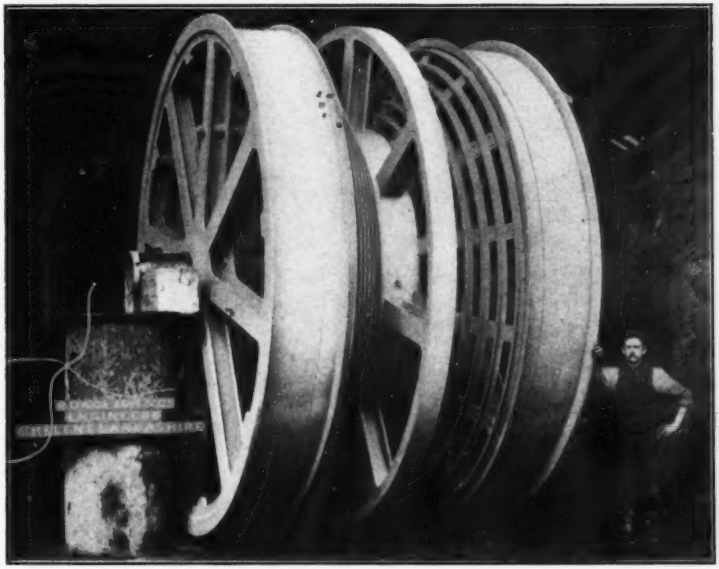
In the early days of mining, before gunpowder was thought of as an aid to the worker, all work, even the most difficult stone work, was done with with picks and wedges. An excellent example of what could be done by means of these simple tools alone is to be



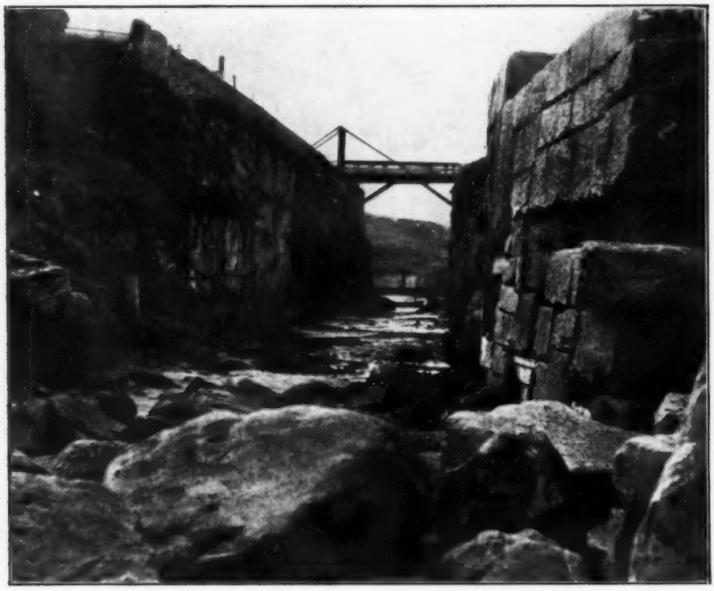
ELECTRIC MINING LOCOMOTIVE, OF 25 HORSE POWER.
Ernest Scott & Mountain, Ltd., Newcastle-on-Tyne.



A MODERN MINE HOISTING ENGINE.
Whiting hoist, as built for South Africa by the Allis-Chalmers Co., Chicago.



A PARTIALLY CONICAL (INTERNAL) AND PARTIALLY CYLINDRICAL WINDING DRUM.
R. Daglish & Co., St. Helen's, Lancs.



PASSAGE INTO SEATON SLUICE HARBOUR, NORTHUMBERLAND. CUT THROUGH THE SOLID ROCK WITHOUT THE AID OF EXPLOSIVES.

seen in Northumberland in the old harbour of Seaton Sluice, now disused, the passage into which was cut out of the solid rock without the aid of any explosive whatever.

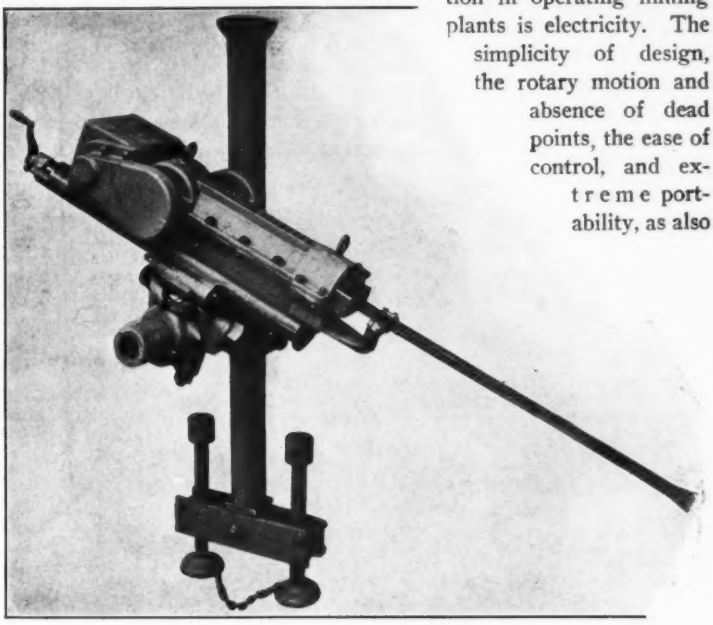
So late as the year 1810, according to a work on coal mining written about that time, the wedge and mallet were the means used to force down the coal, which was then placed on corves, or baskets made of hazel twigs, and drawn by hand, either on a sledge or upon a "train road," to the shaft. Since that time horses and machinery have replaced manual labour in the haulage roads, wedging has been entirely superseded by the use of gunpowder or other explosive, but the arduous task of "undercutting" the coal is in most collieries still performed by hand.

Drilling machines worked by power derived from electricity or compressed air have for a considerable time been in favour in metal mines in all parts of the world, but in coal mines hand drills are still used, probably owing to the softness of the coal and coal-bearing rocks, compared with the older rocks that are tunneled through in metal mines.

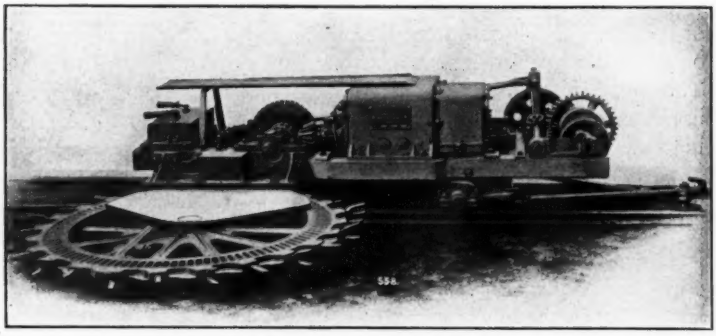
The earliest attempts to make a machine that would take the place of the miner's pick date from the middle of the last century, but it is only in recent years that such machines have come into general favour. The great strides made in electrical engineering, and the increased use of compressed air, are no doubt mainly responsible for the growing extent of their use.

Of these machines there are two main types—the pick or punching machine, and the cutting machine, the former being intended to imitate the action of the miner's pick, while the principle of the latter is a revolving disc, chain, or bar. In England the chief element of opposition to their use has been undoubtedly the cheapness of manual labour, but in the bituminous coal districts of America the high price of labour has enabled coal-cutting machinery to more than hold its ground, in spite of the natural difficulties encountered arising from the highly inclined strata.

The power which seems to be generally best adapted for consumption in operating mining plants is electricity. The simplicity of design, the rotary motion and absence of dead points, the ease of control, and extreme portability, as also



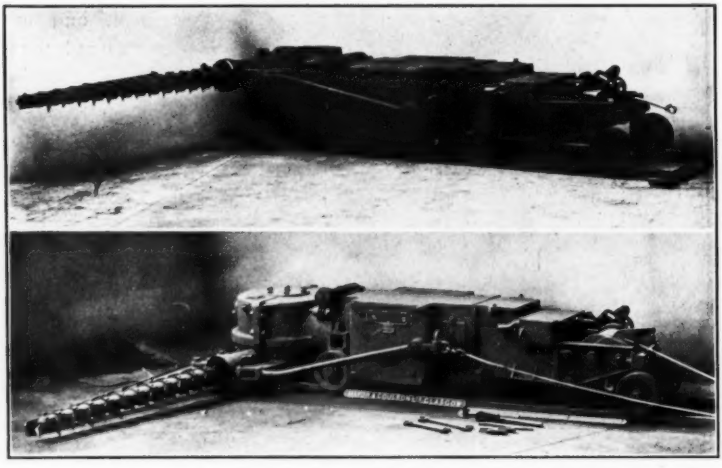
BOX ELECTRIC PERCUSSION ROCK DRILL.
Denver Engineering Works Company, Denver, Col.



DISC TYPE, ELECTRICALLY DRIVEN COAL CUTTER.

Disc 5 feet 6 inches in diameter; 25-horse-power motor. Ernest Scott & Mountain, Ltd., Newcastle-on-Tyne.

the high efficiency which is now obtainable over a modern electrical installation, constitute the electric motor the agency *par excellence* of which the mining engineer may ask aid. Changes and extensions may be quickly made, and the conducting wires can be carried through the most tortuous passages of the mine—qualities which immediately place it above steam and compressed air. The efficiency too, where the

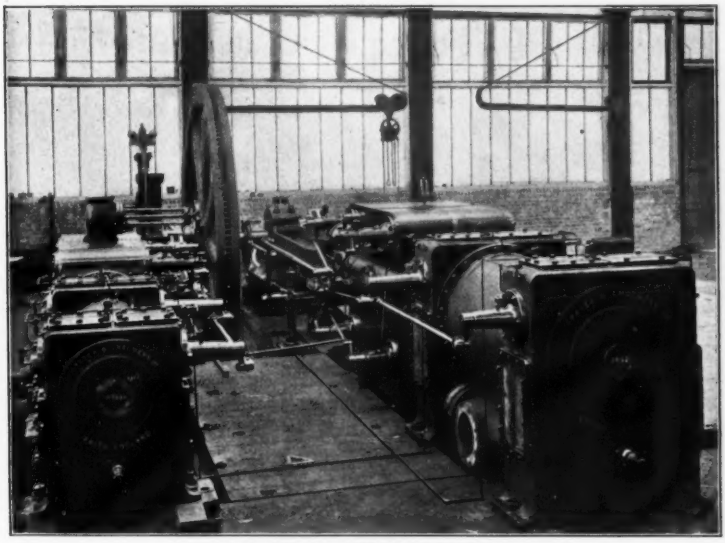


ELECTRIC BAR COAL-CUTTING MACHINE.

In the upper view it is adjusted for over-cutting; in the lower, for under-cutting. Mavor & Coulson, Glasgow.

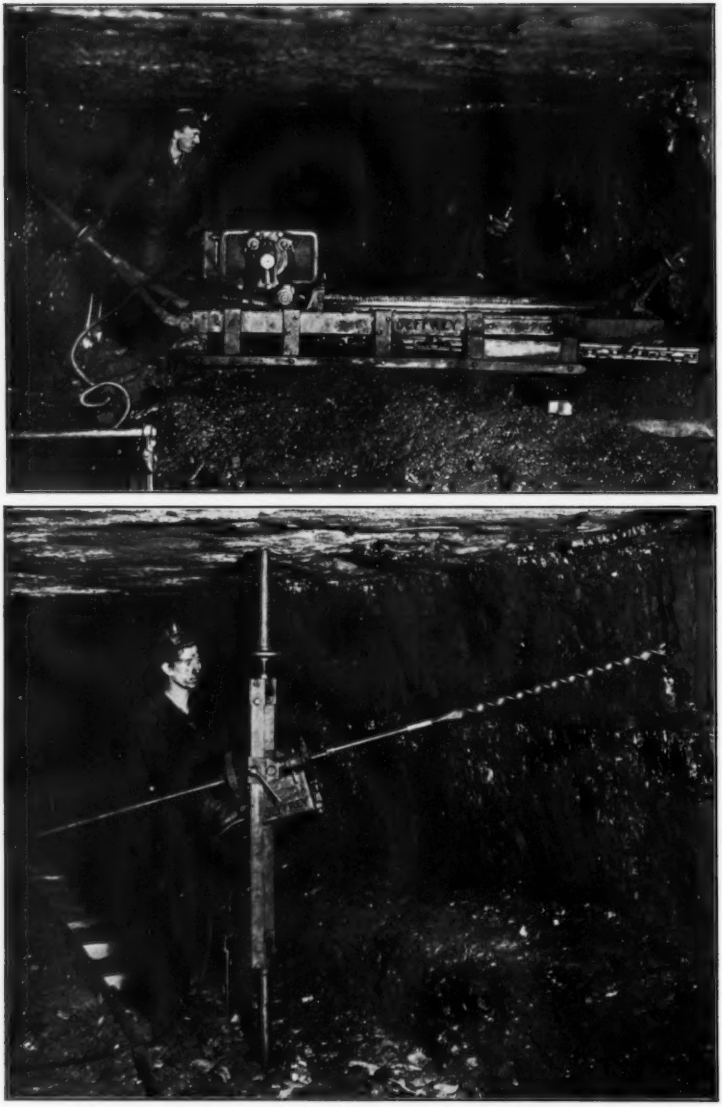
A MODERN MINE. SHAFT HOUSE, HEAD FRAME, AND ENGINE HOUSE, CROWN REEF MINES, JOHANNESBURG.

Showing incline equipped with balers for unwatering the mine after the Boer war. Round ropes, rolled-steel-plate drums, loose on main shaft and connected thereto by powerful band friction clutch. Built by Wellman-Seaver-Morgan Co.

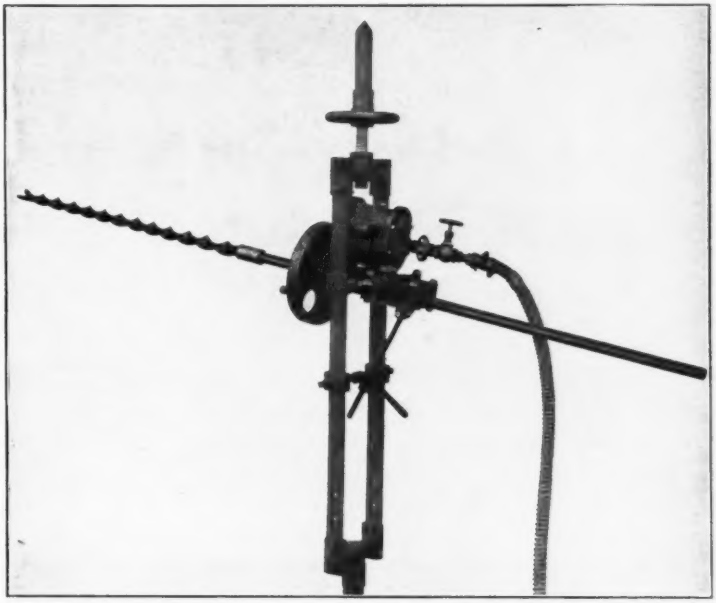


A MODERN AIR-COMPRESSOR PLANT.

3,064 cubic feet free air at 68 revolutions; 75 pounds air pressure with 120 pounds steam, condensing; jacketed steam and air cylinders. Fraser & Chalmers, Ltd., Erith, England.



THE UPPER PICTURE SHOWS THE JEFFERY ELECTRIC COAL-MINING MACHINE READY TO START; THE LOWER THE JEFFERY ELECTRIC COAL DRILL AT WORK.



COMPRESSED-AIR POWER COAL DRILL.

Weight 170 lbs.; effective air pressure 60 lbs.; Jeffrey Manufacturing Company, Columbus, Ohio.

transmission is over some distance, is much greater than either steam or compressed air. Electricity can be used as the motive power for every operation in mining, and in one mining district—Cripple Creek, Colorado—is the only power used, being derived partly from steam and partly from water power.

Taking a comprehensive view of the influence that machinery brings to bear on the working of a mine, one is struck with the general idea of thoroughness of system and method that seems inseparable from its use, and which will undoubtedly have its effect not only in the attainment of greater economy in production, but also in the not less desirable result of lessening the danger to life and limb, and materially diminishing the number of accidents to which, alas! all mine workers are liable.

MECHANICAL AUXILIARIES TO THE ECONOMY OF THE FIREROOM.

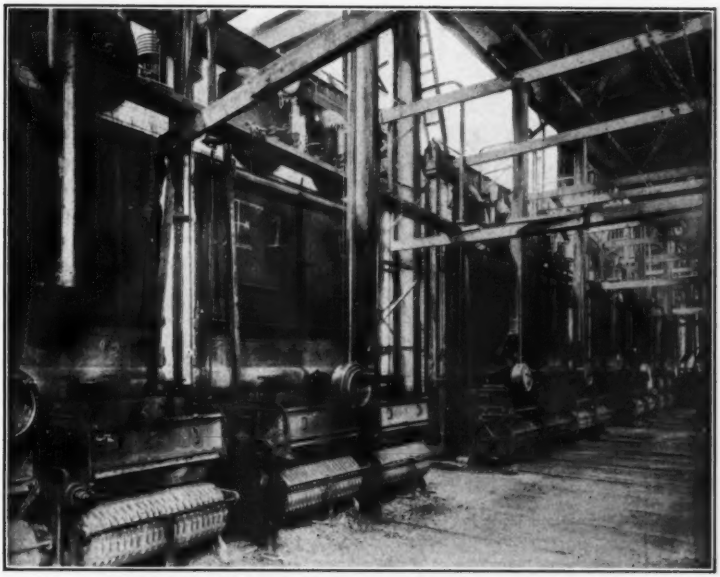
By Reginald Pelham Bolton.

As the use of mechanical power is the great source of labor economy, the power plant itself should certainly be an example of the best practice in economical working. Any useless expenditure of labor or of money there places a burden upon every unit of the output of the establishment, of whatever kind those units may be. And Mr. Bolton's discussion brings out very clearly the point that every extension of the use of mechanical appliances in the fireroom not merely improves the physical conditions of the work, but demands higher mental qualities in the worker. It is a characteristic manifestation of the effect of labor-saving machinery.—The Editors.

WHILE it is fortunately common to find an intelligent attention devoted to the subject of types and designs of boilers, it is unhappily the fact that the general arrangements attendant upon the installation of boilers are, in a large number of instances, afforded relatively scant consideration, in general being abandoned to the deciding circumstances of location and to limitations imposed by other apparatus.

The cost of power production is not all a question of fuel. With it are inseparably connected the costs of burning to proper economy and of handling the fuel. The responsibility for ignoring these matters lies, remarkable to say, at the door of owners of such apparatus. It is rather an illustrative fact that the initial cost of a boiler plant is about equivalent to its coal consumption for one year, and this statement may serve to enforce the importance as well as to indicate the possibilities of economy in all matters connected with it.

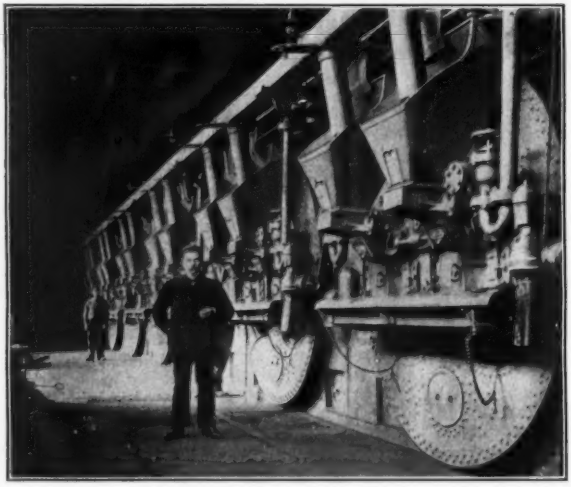
Assuming the purchase of boilers of good form, which contain all desirable elements for the absorption of the heat evolved beneath them, it still remains necessary, in order to complete the effectiveness of their operation, that the boilers should not be placed at a disad-



BABCOCK & WILCOX CHAIN-GRATE STOKERS, PINKSTON POWER STATION, GLASGOW CORPORATION TRAMWAYS.

INSTALLATION OF UNDERFEED STOKERS IN DEPARTMENT STORE OF MARSHALL FIELD & CO., CHICAGO.
The Underfeed Stoker Co. of America, Chicago, Ill.

vantage as regards draft, access, handling, and cleaning. Thus, in any given condition of position, a decision on the adoption of a type of boiler would properly be based not merely on its interior design or constructive features, but on its adaptation to the location. It is hardly too much to say that there is, for any given arrangement of space, a particular form of boiler that is most suitable.



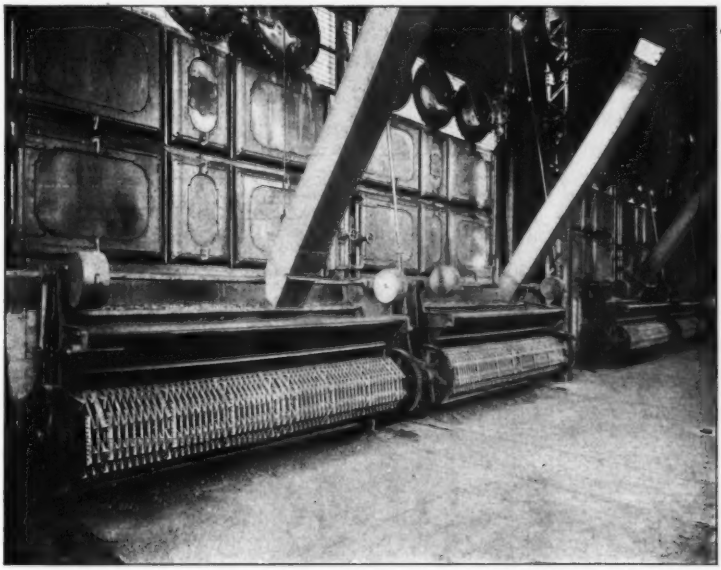
AN INSTALLATION OF BENNIS STOKERS FITTED TO INTERNALLY FIRED BOILERS.

While the elementary conditions require simply the conveniences of handling firing-tools, of drawing tubes, and of access to fuel, it is surprising how often boilers are placed without regard to even such simple requirements. The difficulties encountered in the provision of proper space for such purposes in many buildings are easily to be understood, but many of them disappear when considered in connection with one of the many special types of boilers. But the class of advisers usually employed by owners of such property—namely, the architects of buildings, who endeavor to solve such problems under the limitations of their acquaintance with boiler construction and performance—are, unfortunately, extremely numerous. They look at the matter with the nonchalance of the uninformed, and with the customary confidence of the most self-confident and self-important professional element of any and all ages. Their misguided clients by thousands pay the daily toll of unnecessary waste and extravagance, imposed upon them by their own folly in employing architects, instead of engineers, to decide how

coal shall be burned to advantage. The man who should call in his tailor to decide on his diet would be considered lacking in intelligence, but the owners of property are legion who unthinkingly pay to architects one-twentieth part of its cost to decide, proportion, locate, and limit apparatus actively engaged in eating up their personal assets.

As regards the type of grate and available draft, some decisions are made as surprising as those before referred to. After his plant is installed, it is comparatively rare that a producer of power has taken the trouble to ascertain by comparative test the really suitable class of fuel for his special conditions. Much of such investigating work awaits the engineer in the future.

The multiplication of boilers in one place immediately involves increase of distance from the fuel store, and also introduces the problems of their relation to one another and to the source of draft. Very wide variations are to be found in the arrangements adopted. The most general system is to set batteries facing one another, thus making a central fireroom. This does not possess all the advantages which appear on the face. Practically as much space should be available in



TRAVELING LINK GRATES, KAW RIVER POWER HOUSE OF THE METROPOLITAN STREET RAILWAY, KANSAS CITY, MO.

Green Engineering Co., Chicago, Ill.

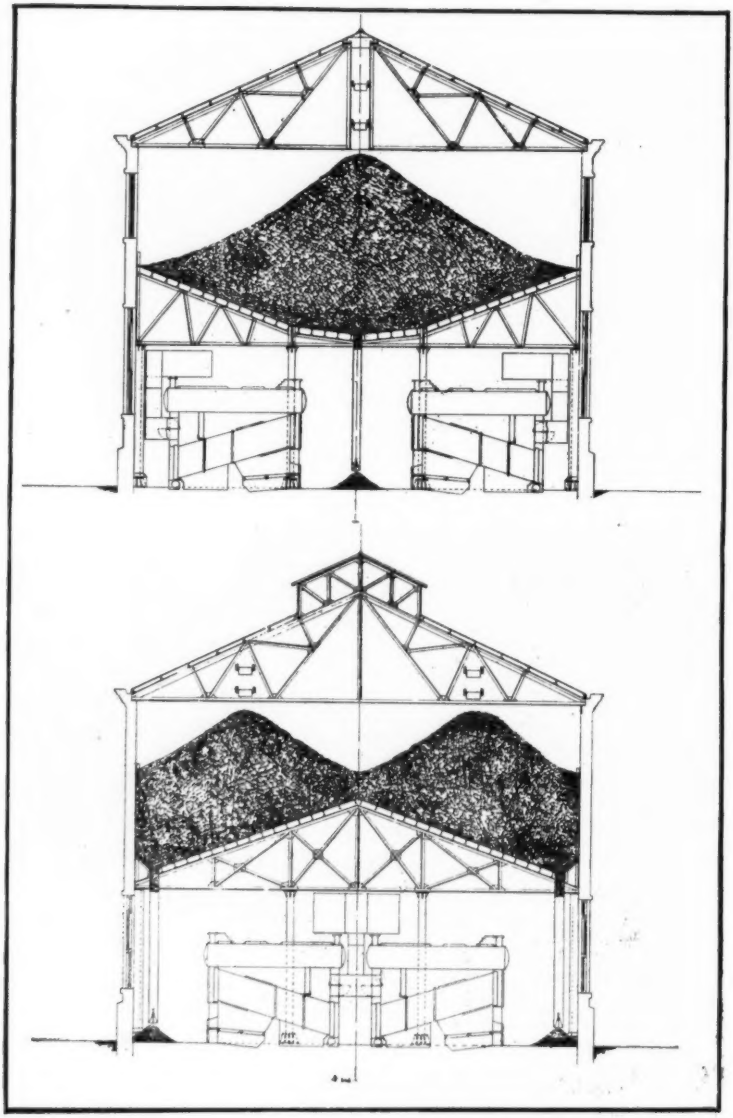
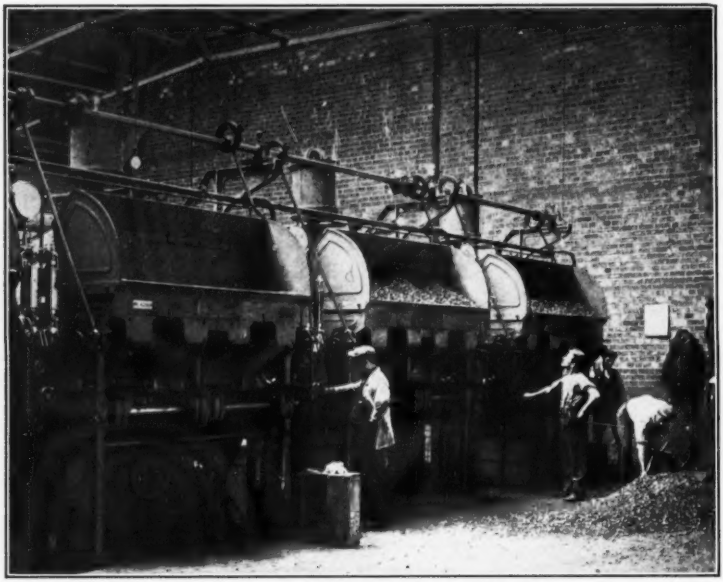


DIAGRAM SHOWING ARRANGEMENT OF BOILERS FACING, AND THE POSSIBILITY OF THE MORE ADVANTAGEOUS BACK-TO-BACK SETTING IN THE SAME SIZED BOILER ROOM.

the central fireroom as in two separate rooms, otherwise the men firing opposite boilers are liable to interfere with one another. I have frequently heard this complaint made by firemen, and in such rooms also the heat radiated from the fronts and fires of both batteries often renders the temperature of the room almost unendurable.

Boilers so designed that they could be set back to back, would lose less in radiation. Such arrangements are more common in Europe. The Popp air-power station in Paris is a good example. Here the boilers set back to back, and each fireroom is light and is ventilated naturally—elements counting for much in the amount and character of work done by the firemen, who seem commonly to be regarded as a class of men capable of doing effective work of a character which peculiarly requires intelligence, under conditions of darkness, filth, and heat, which would be scouted as ridiculous if applied to any other class of labor. Especially is this the case in firerooms on shipboard. Taking into account the fact that a fireman not only stands for a labor cost, which in New York amounts to $720 per annum, but that he may directly handle as much as $10,000 worth of his employer's property, the results of which his carefulness, ability, and even his state of health, may largely affect—it would seem as if more attention should be paid to the conditions under which these employees work. On the contrary, in a very large station the manager quite recently told me that they picked up firemen anywhere and let them go ahead and fire in their own way, keeping some control of the results by retaining the handling of the draft of each boiler in the hands of a water tender. This illustrates the process of reduction of the fireman to a mere shovelling machine, with just sufficient knowledge to be able to tell when a hole is showing in the fire, and not enough judgment to avoid unnecessary opening of the fire door.

In all other trades some system exists of training men to their work. But in this, the most elementarily important craft, the men are allowed to pick up the knowledge hap-hazard, one by shipping on a vessel burning soft coal burned under furious forced draft—another in a saw-mill shovelling sawdust, wood, and coal alternately—another in a hard-coal battery, and so on through the gamut of possible variations of fuel and draft. A school of training for firemen would present a large opportunity of advantage, and its graduates should find great openings for advancement. When special results are to be obtained from a boiler, it is customary to find an expert fireman employed, whose ability not infrequently has attained results unattainable by the ordinary employee. What one such man can do might just



VICARS' STOKERS APPLIED TO LANCASHIRE BOILERS, POWER STATION OF THE HULL CORPORATION TRAMWAYS.

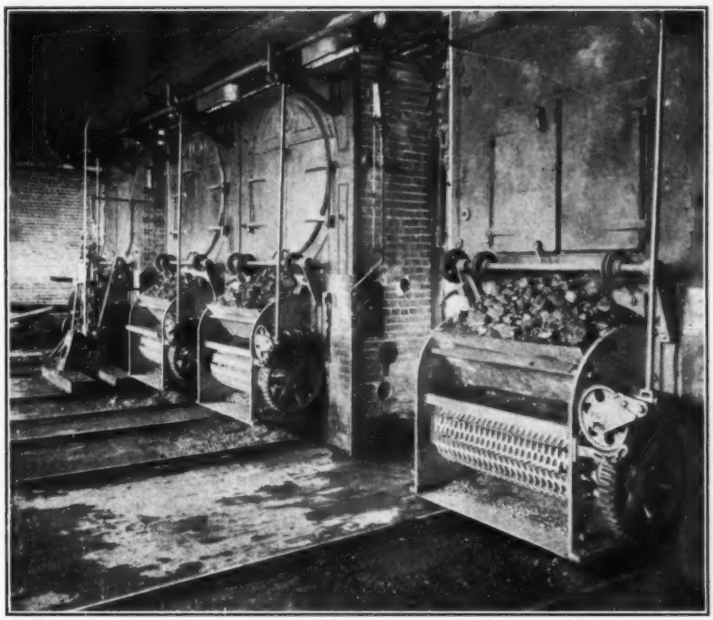
as well be done by others. Yet owners frequently express hostility to the employment of such a man on boiler-economy trials, designating their work "fancy firing," and belittling the results. The lesson afforded to the regular employees is sometimes ignored—more rarely accepted.

There are probably more than three thousand men employed in New York city alone in shovelling coal into fires, so that the opportunity for improvement is great. This state of affairs is one of the chief reasons for argument in favor of the adoption of automatic apparatus, which are almost to be characterized as legion. It would not be possible within the limits of this article to enter into an analysis of their respective merits and advantages. The main features developed by the experience of users seem to be that the use of automatic stokers is advantageous in installations in continuous and regular use, but that where fuel varies in character and in quantity required to be burned, hand firing still shows advantages. The result in some large installations, where the load is variable, is that automatic stokers are utilized in a certain portion of the plant, affording a practically fixed output or within moderate limits of variation, and hand firing

is utilized on the remainder of the battery for variable and for emergency output. This result is much the same as has been experienced with all other forms of automatic apparatus, which leave, after all, a certain use for manual labor.

In the adoption of automatic stokers it does not necessarily follow that the fuel must automatically be supplied to them. There are, of course, many cases where this cannot be done, and the employment of firemen or coal passers is continued, to lift the fuel to the feeding hoppers. In large modern installations, however, the mass of fuel is elevated and stored in quantity, and arranged to be delivered by gravity to the desired point. For such work the smaller sizes of anthracite are peculiarly adapted, especially in what may be called "interior installations"—those inside dwellings and factories.

Automatic firing has certainly a pleasing aspect as a general proposition, but has produced quite as large a crop of disappointment as of satisfaction. This has been due largely to the lame method of adapta-

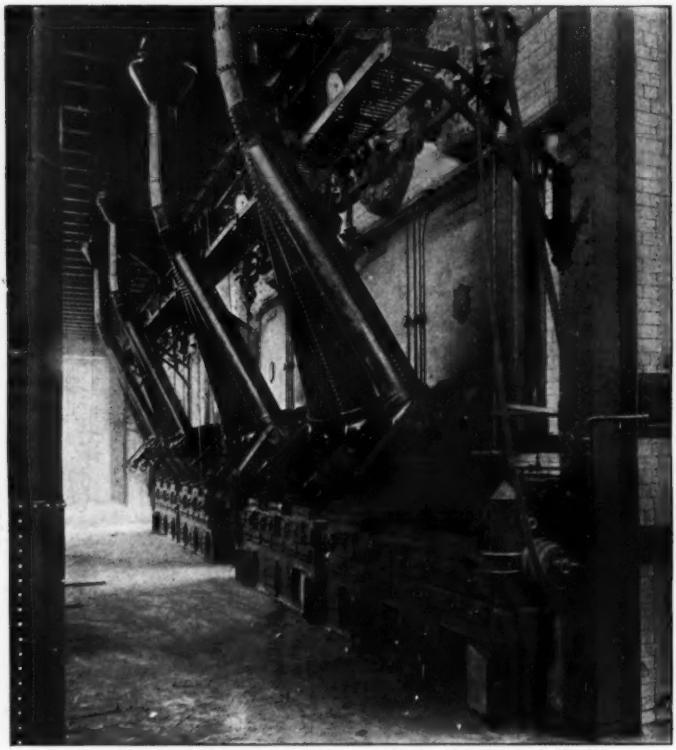


AN INSTALLATION IN THE BOILER PLANT OF THE SUPERIOR SHIP-BUILDING CO., WEST SUPERIOR, WIS., BURNING RUN-OF-MINE COAL.

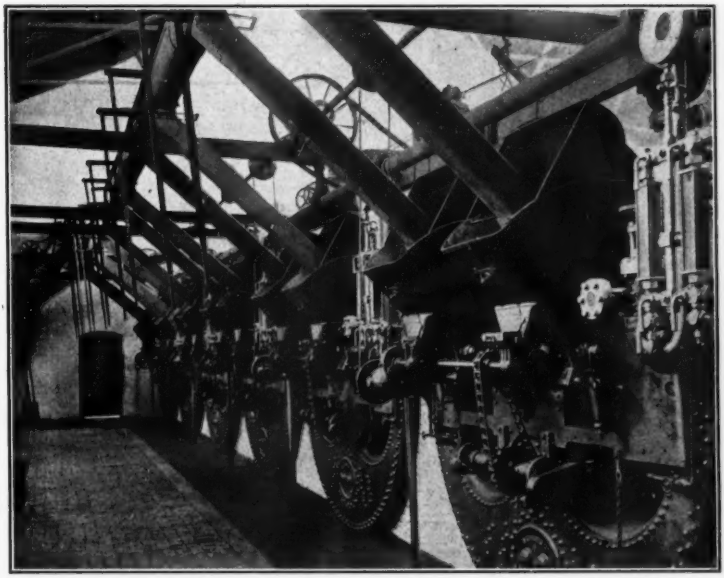
Duluth Stoker Co., Duluth, Minn.

tion of apparatus on the responsibility and recommendation of patentees and manufacturers, and owners of plants have in many instances only themselves to blame for accepting the seductive proposals blandly made to them by insinuating agents, without taking some technical advice. There are stokers and stokers, some of them utterly unsuited to conditions which would produce excellent results with other types. It is quite certain that in one, if not more, of the great power houses in New York, stokers are working at a loss, and a visit to the rear of their boiler batteries and a climb over the piles of burned-off grate bars, will bear testimony strongly in favor of this view.

One power house has stokers which are expected to work on hard or soft coal, as it may happen to reach them. Another has, as above



INSTALLATION OF COKER STOKERS, BRISTOL ELECTRICITY WORKS.
Meldrum Bros., Limited, Atlantic Works, Manchester.



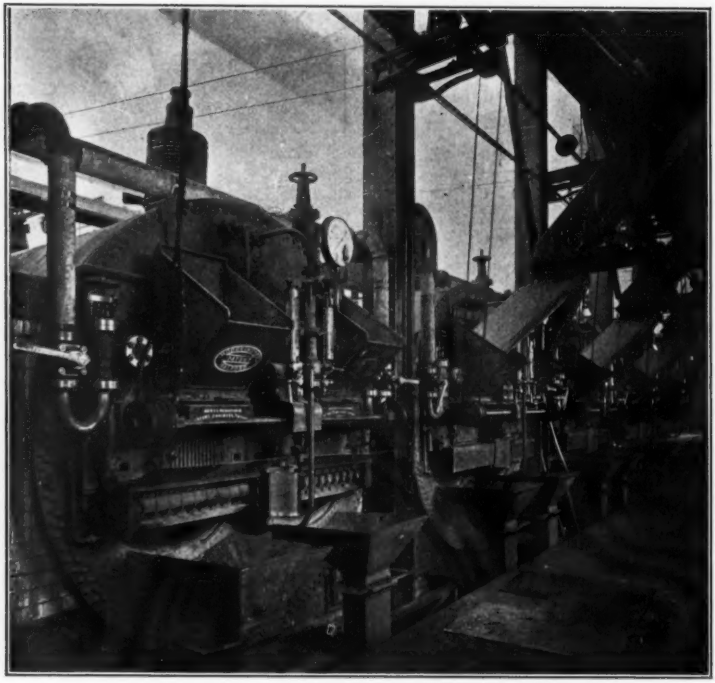
PROCTOR'S SHOVEL STOKER APPLIED TO FOUR EIGHT-FOOT LANCASHIRE BOILERS, NEW HYDRAULIC STATION OF NORTHEASTERN RAILWAY, MIDDLESBORO.

The stokers are fitted with a complete coal-handling plant, delivering coal automatically to the stoker hoppers by elevators and conveyors. Proctor, Burnley, Lancs.

mentioned, cut the difficulty by installing stokers under only one-half the plant. These are plants designed under the "committee" system, in which a number of engineers are brought together from different parts of the country and are directed to settle in concert the various questions of type, design, and economy. The vital details are worked out by the cheap staff of the corporation. This method produces the diverse and often confusing arrangements which can be compared by a trip from 38th street to the Harlem. It is natural that in such haphazard combinations, the stronger will dominates the weaker, and therefore, in the work of one such committee may be seen the dominance of Cincinnati or Chicago, and in another that of Boston or Baltimore, while the underlying local conditions have to take a back seat.

It is interesting to observe the effect of these sporadic efforts of great corporations to avoid placing responsibility on one man's shoulders, and above all to evade the cost of employing experts on details.

A common allowance of labor for the purpose of firing is to allot



AN INSTALLATION OF HODGKINSON'S STOKERS AT THE NEW SALFORD ELECTRIC-LIGHT STATION.

James Hodgkinson, Salford, Manchester.

one man to a rating of 500 horse power. This a very variable quantity, since that capacity may, under conditions of economy or extravagance, require the burning per hour of 1,500 or 2,500 pounds of coal, a difference of nearly two to one. Marine practice allots a man to 54 square feet of fire-grate surface—an attempt to provide a man to three ordinary furnaces of an interior-fired return-tubular boiler; but here again conditions vary so greatly that the area so allotted may require the handling, under conditions of forced or moderate draft, of quite as great a difference in material. So that in making any comparison with the use of automatic stokers the particular conditions must be examined. On an assumed basis of the employment of six men to 3,000 horse power, handling, say, from 9,000 to 11,000 pounds of coal per hour, the use of automatic stokers may, with the same economic results, be taken to save 1/5 of the labor bill when

the men are still employed to feed the coal to the apparatus. With the use of automatic coal-conveying apparatus or delivery by gravity to the stoking hoppers, the labor would be reduced to that of two men. They should however, be of a better paid (because better informed) class, so that the relative reduction in terms of wages would be approximately only about one half. This matter settles itself in large cities, where the firemen are under any circumstances required to be licensed. More exactly figured, the comparison works out as follows, on a plant in which I have had the opportunity of making a close comparative observation and calculation of the costs under mechanical and hand-stoking methods of firing.

The plant consists of 3,000 boiler horse power, evaporating just over 9½ pounds of water from and at 212 degrees, per pound of dry coal, and when fully occupied the men may handle, with 2 per cent. of moisture in the fuel, a weight of about 11,000 pounds per hour. Such a battery would consist of, say, 10 units of 300 horse power each, and under New York city conditions, with natural draft, would have from 600 to 850 square feet of grate surface.

The operating force required for a 24-hour load service, 12 hours day load with easy firing at night on three to four boilers, 10-hour shifts, is as follows:—

I.—Hand firing.

	Wages.
Two men, 1 p. m. to 10 p. m., clean fires at 8 p. m., one at	$ 720
and one, being a leading fireman, at	800
Two night firemen, keep steam 10 p. m. to 8 a. m. and clean fires before 8	1,440
Four firemen, come on 8 a. m. to 6 p. m., and clean fires 12 and 4	2,880
Water tender on duty 8 a. m. to 6 p. m.	840
Three coal passers, 6 a. m. to 6 p. m.	1,512

The arrangement gives:—

Four men and water tender from 8 a. m. to 1 p. m., when moderate load is required.
Six men from 1 p. m. to 6 p. m.—heavy load.
Two men from 6 p. m. to 10 p. m.—decreasing load.
Two men from 10 p. m. to 8 a. m.—night load.

Total wages per annum $8,192

II.—Automatic Stokers, hand-fed.

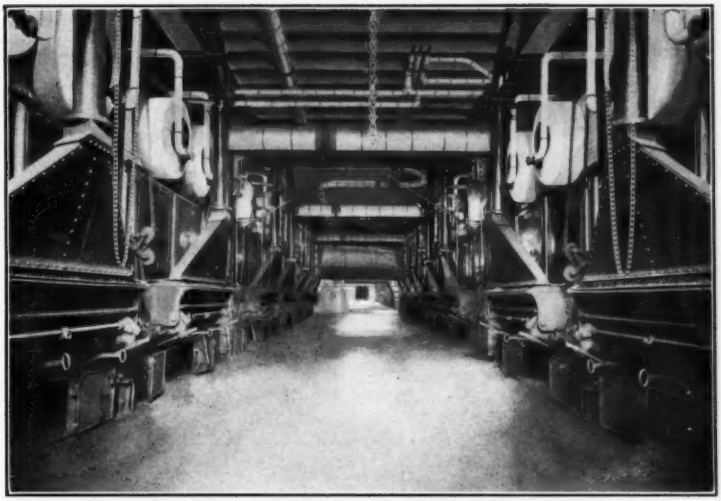
With automatic stokers the same class of labor must be employed, as the men must be licensed firemen. Two men must be kept on at night in case of accident to one. Night work and day work reduced to lifting coal to hoppers; no cleaning of fires.

	Wages.
Two men, 1 p. m. to 10 p. m., as above	$1,520
Two men, 10 p. m. to 8. a. m., as above	1,440
Two men, 8 a. m. to 6 p. m., as above	1,440
One water tender	840
Three coal passers, as above	1,512
This arrangement gives four men between 1 p. m. and 6 p. m.	
Total wages per annum	$6,752
Add part of engineer's wages in maintenance of stoking apparatus, say, one-third of an assistant engineer's,	$320
Interest on cost of stokers, say, $10,000 at five per cent.	500
Depreciation and replacement of bars, say	680
Total	$8,252

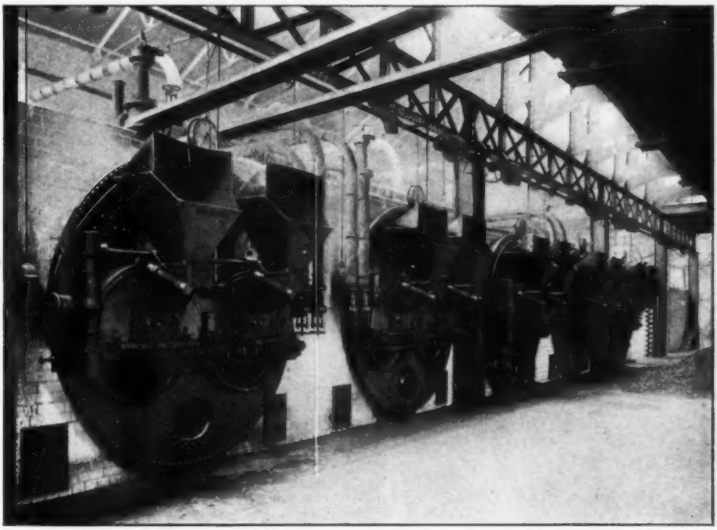
Thus the combination of circumstances and of requirements here shows a loss by the mere adoption of automatic stokers.

It would be argued however, by exponents of such apparatus, that the stokers would enable less boilers to be operated at a higher rate of evaporation and that this would reduce the labor involved. But against this view must be considered the fact that the labor of coal lifting is already enlarged by the increased heights to which, in most such apparatus, the fuel must be lifted to the hoppers. Further, even were the total coal labor considerably reduced, it would not, in such a plant as this, permit a further reduction of labor, because the security of a large battery and the increase of maintenance of the supply demands the attendance at all times of not less than two men.

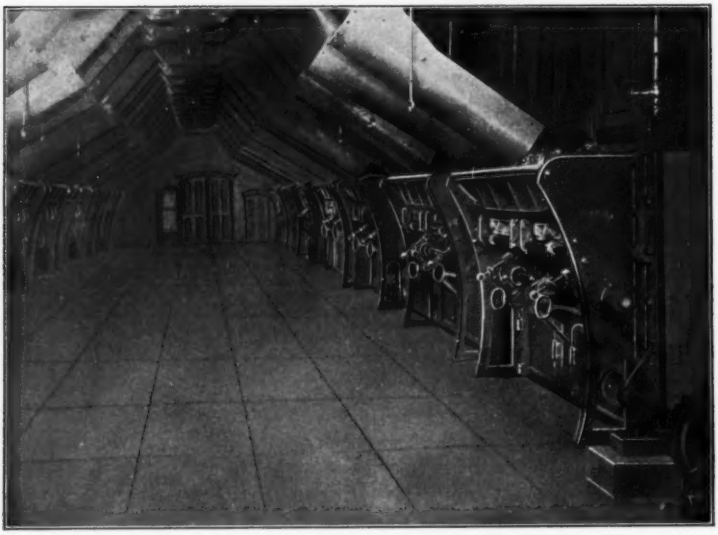
The results to be effected by the addition of these stokers of coal-handling apparatus or gravitating arrangements puts a better complexion on the question, because it immediately dispenses with the services of two out of three coal-passers costing $1,512 per annum, the third being necessarily retained for handling ashes out of the fire-



RONEY MECHANICAL STOKERS, 96TH STREET POWER HOUSE, METROPOLITAN TRACTION CO., N. Y.
Westinghouse, Church, Kerr & Co., N. Y.



INSTALLATION OF TRIUMPH STOKERS AT THE NEW CORPORATION ELECTRICITY-SUPPLY STATION, HYLTON ROAD, SUNDERLAND, DURHAM.
Triumph Stoker, Limited, Ransomes & Rapier, London and Ipswich.



4,000-HORSE-POWER BOILER INSTALLATION FITTED WITH ROSS STOKERS, CLARION MILL OF THE NEW YORK & PENNSYLVANIA CO., JOHNSONBURG, PA.

room. Furthermore, as there is now no labor for the firemen, no more than two need at any time be kept on duty, and of these the water tender will answer for one during his hours of duty, so that we get by a re-distribution of labor:—

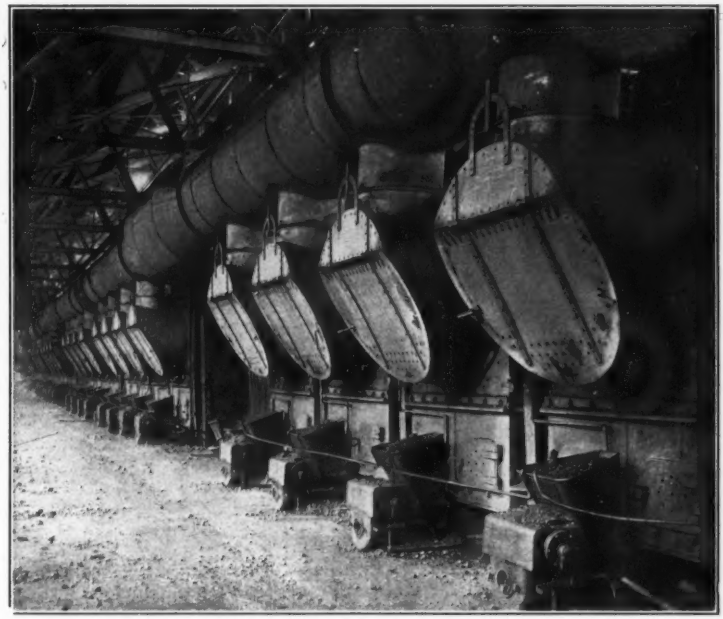
One water tender, 8 a. m. to 6 p. m.	$ 840
One fireman, 4 a. m. to 2 p. m.	720
One " , 2 p. m. to 12 midnight	720
One " , 6 p. m. to 4 a. m.	800
One coal-apparatus tender 7 a. m. to 7 p. m.	600
Interest, replacement, and depreciation on automatic stokers, as above	1,180
Interest and depreciation on coal-handling apparatus, at 12 per cent. on $6,000	720
Proportion of engineer's wages, say one-fifth of $960	192
	$5,772

This shows an attractive saving of $2,480 per annum, or about 4½ per cent. of the total cost of the plant, and a similar proportion of the coal bill. Therefore if the physical conditions of the situation of the boiler room permitted the use of the coal-handling plant, then

the use of automatic stokers would be, in this case, desirable. As a matter of fact, in the particular plant from which I have drawn this illustration, considerable physical obstacles existed, and there was a further objection on the part of the owners to the possible vibration or noise from the use of such apparatus below their building.

I am free to admit that in much larger boiler plants, the minimum labor element would bear a less proportion to the whole, and consequently relative economies would be greater. Therefore, it is probable that the point at which a hand-fed system of automatic stoker will show an economy in labor, will exist in a battery of some proportion exceeding 3,000 horse power.

Undoubtedly much economy in the betterment of evaporative results has been obtained in many instances by the application of automatic stokers, but it should be demonstrated, before crediting this result to the apparatus, that the same amount of improvement might not have been effected in other directions. Thus, it will be observed



AMERICAN STOKERS, UNDERFEED SYSTEM, AT THE HOMESTEAD MILLS, CARNEGIE STEEL CO., UNITED STATES STEEL CORPORATION, PITTSBURG, PA.

American Stoker Co., N. Y.

by a comparison of some of the claims of, and of the tests run upon automatic firing, that they usually attain high results by running up the output of the boiler, or in other words by working it over its "rated" capacity. There are numbers of boilers which could be improved in their performance by the same treatment under hand firing, because the "rated" capacity is in just so many instances "under-rated," by reason that the "rating" ignores the fuel and draft conditions.

When the conditions admit of the gravitation of the fuel to the fire room, and of the gravitation of the ash and clinkers to receptacles below, a very ideal condition is reached, removing the cost of labor in handling, and eliminating much of the unintelligent class of labor from the installation, but introducing the new element of the employment of men capable of handling motive machinery. Such mechanical additions to the fire room tend to increase, in the form of coal crushers, forced-draft systems, coal and ash hoists, and mechanical tube cleaners. For much of the work of the fireman and coal passer, is substituted a percentage of the steam power raised.

An element of large capability of economy which is in wide use on shipboard, is not yet much availed of on land, viz., the use of heated forced draft, which in the hands of skilled operators affords considerable future possibilities. It may here be mentioned that systems of forced draft by steam jets or by fan, are liable to misuse by ignorant firemen, even to the extent of throwing upon their fellow laborers part of their own share of work. The common system of connecting all boilers of a battery together, affords no opportunity of comparing the work of one fireman or one boiler with another. It is not uncommon to see conditions where one boiler is doing no work at all, while its neighbor is forced over its rating.

All these considerations lead back to the fundamental requirement of human intelligence in the fire room, and the need for such intelligence is not lessened by the march of modern improvement, but rather increases. There will not be, even with a much more general adoption of automatic apparatus in the smaller class of installation, any less need for knowledge on the part of firemen, or even of the more mechanical attendants upon modern automatic apparatus.

Courses of study in firing and kindred subjects could with advantage to the community at large, be established by our colleges. It is a subject which directly and greatly affects the pocket, as well as the resources of the nation.

THE RELATION OF ELECTRIC INVENTIONS TO HUMAN ACTIVITY.

By Louis Bell.

It is plainly impossible even to list the myriad special applications of electricity. Dr. Bell therefore discusses only the great fundamental inventions, but with rare discrimination in apportioning their influence, and with even rarer interest in the presentation of the subject.—The Editors.

ONE is very apt to confuse the bearing of inventions upon human affairs by mistaking inventions of convenience for those that produce a deep and lasting effect upon civilization through profound changes in the efficiency of industry. The inventions which directly increase the scope of a man's efforts, mental or physical, stand on a very different plane in relation to the world's progress from those which merely give him new luxuries or employments. Viewed in this perspective, the advances of the nineteenth century take on an appearance altogether different from that which they present at a casual glance.

We live, for better or worse, in a work-a-day world, and those evolutionary changes are most effective which diminish the effort required for producing necessities and thus set free time and activities for racial progress. No people ground down by eternal toil can advance rapidly, mentally or physically—least of all, spiritually. The effect of the inventions of the last century in liberating human energy for use in general progress has been tremendous, and in this great work the electrical advances of the latter half of that century have played an important rôle.

Yet they have a certain scintillant quality that tends somewhat to exaggerate their real effect upon civilization as a whole. For example, no electrical invention has produced results so deep and far-reaching as the locomotive or the steam boat, and very few have reached the importance of the power loom or the sewing machine. Very possibly the importance of the former pair may not again be equalled for centuries to come, and it is altogether improbable that the present century will equal the past one in its achievements, so far as fundamental inventions are concerned. We shall see numberless scientific

discoveries and inventions of convenience. A type of the latter class was the invention of photographic processes.

The first notable electrical invention of the nineteenth century was the electromagnetic telegraph. The story of the struggles and triumph of Morse and of his associates is a dramatic one, and the final result, girdling the earth with cables and covering it with a network of communications, has had an immense effect in improving the mechanism of commerce and facilitating the distribution of industrial output. Yet this involves only an indirect effect on the conservation of human energy. It would be very interesting to know the actual number of separate persons who send and receive telegrams yearly, but the total would probably be surprisingly small, and of the telegrams sent only a rather small proportion would prove to be of such a character as not to be replaceable by letters without any industrial or material loss. Of the value of telegraphy in the dissemination of news there is no doubt, and yet it would be hazardous to say that anyone is sensibly wiser, happier, or richer for knowing within six hours the repulsive details of a massacre in Macedonia or a lynching in Oklahoma.

But the electromagnetic telegraph, although from the purely industrial standpoint it fails of being an invention of the highest rank, still was a tremendously potent factor in electrical advancement. It was the first brilliant success in the applications of electricity, and it stimulated research to an extent that can hardly be realized by those of us who belong to a later generation. Telegraphy was the first, and for years the only, school of electrical science, and its graduates were in no small degree the moving force in later improvements and discoveries. And telegraphy itself called forth inventive talents of a very high order. Edison's work on the "ticker" and the "quad" would have given him a conspicuous place among the great inventors of the century even if he had accomplished nothing else.

Telegraphy was the one vital stimulus of electrical science for at least a quarter of a century. And then came that epoch-making and incomparable improvement, the invention of the dynamo electric generator. Like many another great invention, it can fairly be ascribed to no single person, although the names of Siemens and Gramme will always be those most intimately connected with its history.

The dynamo gave at last the power of obtaining electrical energy in any required quantity by a direct transformation of mechanical energy. It made it possible to draw without limit on the eternal forces of nature for energy in its most versatile form. Without the dynamo, no serious industrial use could be made of elec-

SAMUEL F. B. MORSE. 1791-1872.
Studied art under Benjamin West, and was one of the founders of the National Academy of Design. Began work on the electro-magnetic telegraph in 1835, and established the first line, by United States Government aid, in 1844.

tricity; with it, the whole mighty growth of the electrical arts became almost a matter of course. Before the change could be realized, the laboratory experiments of a quarter of a century became fully commercial enterprises, and struck out new arts. Sooner or later the fruits of research are always reaped by humanity, and in this case the harvest was incalculably great.

The reversibility of the dynamo was a corollary of its invention, and the electric motor, the most striking recent addition to industrial powers, quickly made its way into the world's workshops. It took a few years to bring the world to a realization of what the electric motor could do, but from those first experiments at Sermaize in 1878 has come an industrial force that can hardly be overestimated. The names of Chrétien and Félix are today half forgotten, but they should be blazoned high as the pioneers in the utilization of electric power in both stationary and moving motors. Others had talked and experimented and built models—Chrétien and Félix did the thing itself, in a practical way and for a practical purpose. Aside from all its facility of application, and its marvellous adaptability to labor-saving methods and mechanisms, the electric motor has given mankind the power of controlling and utilizing natural forces in the industrial arts.

The continual draft on the world's fuel supply, which even now menaces the permanence of industries, cannot be checked save by the utilization of permanent natural sources of energy—water power, and wind power, and sun power—in lieu of the limited and stored energy represented by coal. And such utilization today practically depends upon the electric motor. The centers of human industry at the present time are in regions depending upon fuel, not only for their supply of energy, but for their very habitability. Mankind is like a reckless spendthrift throwing to the winds his heritage of energy and sooner or later—perhaps sooner than we think—the end must come. Then must ensue a world struggle for the maintenance of the conditions of existence, and the only hope will lie in the natural powers that, arising in the last resort from solar radiation, will last until the sun grows cold.

But before the electric motor began its momentous career there came, almost like a thunderbolt out of the clear sky, an electrical invention so startling and sensational in its character, so brilliant in its conception and of such prodigious usefulness in its results, that it will probably be written down in history as the most striking single invention of a century almost uniquely productive of marvels. The speaking telephone occupies a place quite by itself. It comes nearer to black magic than anything of human devising since the dawn of history.

MICHAEL FARADAY, F. R. S. 1791-1867.

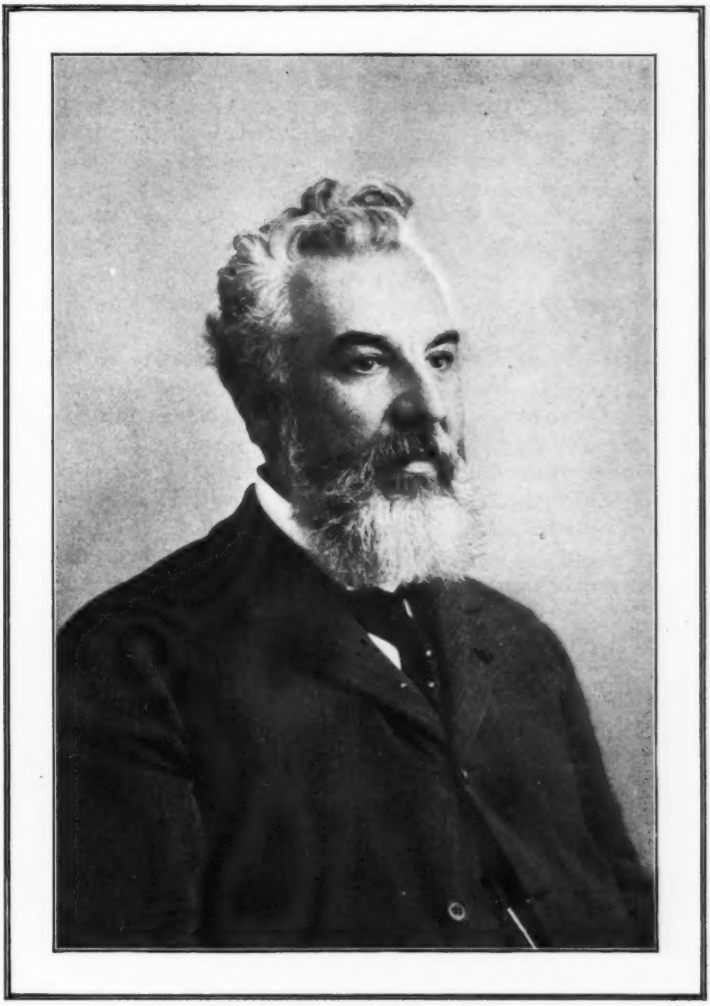
From Phillips' portrait, National Portrait Gallery. Copyright by Walker & Cockerell.

Famous for his work in experimental chemistry, electricity, and magnetism. While his work was exclusively in pure science, he laid the foundations on which the later inventors based their practical discoveries and industrial applications.

As an energy-saving device the telephone far outranks most inventions classified as great. Within its own particular sphere of usefulness—the saving of time in necessary communications—it is incomparably more efficient than the telegraph, since it can accomplish in a three-minute conversation more than could be done by the interchange of half a dozen telegrams extending over a couple of days. More than this, it has an immense value in local communications which are without the field of telegraphy. Aside from its importance in saving the time of business and professional men to an extent which can hardly be calculated, it also takes a very high rank as an invention of convenience, in facilitating general communications of purely personal interest. It bears a relation to that part of industry which does not directly depend upon manual effort comparable only to the substitution of automatic machinery for hand work, and in its relation to the industries and methods of a complex civilization it should perhaps take place as the greatest single invention, aside from printing and the railroad.

In case of the telephone it is possible to get an approximate idea of the extent to which it is used in everyday affairs. In the United States alone there are in regular use close on to two million telephones, so that it would probably be well within bounds to say that ten million people come within their sphere of influence. As many more may probably be reckoned as occasional users of telephones, so that the sum total rises to twenty or twenty-five per cent. of the whole population. This is the more remarkable as the telephone is unrelated to the ordinary labor-saving devices which one naturally expects to find in very extensive use. It does not, of course, reach to the very roots of industry, as do inventions which increase the efficiency of manual labor, or bring to hand the forces of nature; but outside these basic considerations its position is unique.

Almost simultaneously with the telephone the art of electric lighting was developed. The idea was not new to the time, for both arcs and crude incandescents had been known for many a year; but the substitution of the dynamo for the battery made possible as a commercial enterprise what had before been a mere laboratory curiosity. How great has been the growth of the art he who runs may read. There has been no one great invention in electric lighting save the high-resistance incandescent lamp, but the art has grown up through a multitude of small inventions and adaptations, all bearing forward toward progress, and so interlocked that it is hard to pick out any one which is not inseparably linked with several others. In the financial evidences of material progress, in capital invested, yearly



ALEXANDER GRAHAM BELL. BORN 1847.

Inventor of the telephone, for which patent was granted Feb. 14, 1876. He was professor of vocal physiology, Boston University, and a student of the art of enabling the deaf and dumb to enunciate intelligible sounds. Transmitted musical tones by an electric circuit in 1873, and made a practical telephone for the transmission of articulate speech in 1874.

earnings, the stimulation of electrical manufacture, and in commercial importance generally, electric lighting is a mighty addition to the resources of civilized communities. Yet, oddly enough, it cannot be reckoned as either touching deeply the foundations of industry or as acting directly upon human efficiency. Doubtless, communities are upon the whole better ordered through the brilliant illumination that the electric light has made possible. Doubtless, too, this illumination has tended to the production of more and better work in manufacturing establishments. But electric lighting could pass out of existence in the next decade without affecting deeply either other industries or the general progress of civilization. Its strongest hold on permanent importance lies in the fact that it enables the necessary work of artificial lighting to be done, if need be, without drawing on the world's supply of stored energy. It seems at first sight rash to relegate so great and in itself so important an industry as electric lighting to a secondary order of importance, yet if the touchstone of permanent values be the conservation of human energy, just this step must logically be taken. But it must not be forgotten that electric lighting has done for the development of dynamic electricity just what the telegraph did for voltaic electricity. It has been the school of electrical progress.

The electric railway belongs in a different category, in virtue of its intimate connection with the daily life and labors of the community. In and about urban communities a vast majority of the population directly derives benefits from electrical traction. The electric railway, by enormously increasing the facilities for transportation, lightens the burdens of a large part of the community, and gains time for labor or other purposes to an extent that produces a profound effect in the better utilization of human energy.

In the first place, as an absolute saver of time the total effect of the electric railway is enormous. The time spent in transportation is a net economic loss, for it is unproductive, and unlike well ordered recreation, it has no secondary value as a mental and physical tonic. The time saved from transportation must rank as an economic gain, and the electric railways are especially valuable in this connection from the fact that they are of daily utility to the people who work either with hand or head.

The electric railways of the United States carried last year the enormous total, in round numbers, of *six billion* passengers. If the average saving of time per passenger be reckoned at only ten minutes, the annual clear saving of useful time rises to a hundred million ten-hour days. Imagine nearly three hundred thousand people working or

playing ten hours per day the year round, and you gain some notion of what the electric railway has done in saving time in the United States alone. But even this by no means tells the whole story of benefits received. The advent of this form of rapid transit, in gaining time of transit, has practically doubled the available areas of cities and towns, and has thus relieved to a very material extent the physical, moral, and pecuniary strains that come from overcrowding. One can hardly estimate the actual value of this work, but it can be seen in growing villages, in workmen's homes, and in healthier recreations the country over.

And aside from this, the immense network of transportation which has grown up is having a powerful influence in breaking down the barriers of isolation in the country districts and in establishing new centers of industry. Every year sees electric traction stretching further out and gaining in speed and facility, so that it is no idle dream to look forward to vastly greater benefits in the future. And here again the transference of the energy supply from stored fuel to the constantly renewed natural sources of energy is a splendid economic result.

In its larger aspects the electric railway is the greatest achievement of electrical progress up to the present time. All the applications of electric motors bear powerfully upon the economy of human energy, many of them directly upon labor saving in the narrower technical sense of that term; but none has had so immediate and vital effect upon the community at large as electric traction.

Very intimately connected with the wider ramifications of electric traction is the art of electrical power transmission, which, like electric lighting, has grown up by a succession of interwoven inventions. No one of these, save perhaps the polyphase system, is pre-eminently responsible for the results that have been achieved, and this is connected alike with lighting, traction, and motive power. But the mere fact that about two million horse power in polyphase generators are in use in the United States is a sufficient indication that the system has at present a dominant value in the electrical transmission of power. The fundamental value of power transmissions lies in the fact that by enabling natural forces to be utilized at any desired place, it enables industrial operations to be carried on at the most advantageous points. It incidentally cheapens power in many regions and tends strongly to equalize economic conditions of manufacture from place to place. Electric traction and electric power transmission between them are capable of increasing many times over the area available for successful industry, thus avoiding the economic waste that comes from unnecessary

THOMAS ALVA EDISON. BORN 1847.

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Began as a trainboy on the Grand Trunk Railway; learned telegraphy, and became one of the most expert operators in the Western Union Telegraph Company. His remarkable series of inventions began with the duplex telegraph, in 1870, and his work still continues.

transportation both of persons and material. It would be vastly interesting to compute the needless expense entailed by the concentration of industries in large centers of population. People are sometimes inclined to applaud such concentration, as if mere bigness were a virtue; but to see the other side of the question, consider what would be the result of trying to concentrate the cotton manufacture of the United States within the corporate limits of New York city. The only real gain resulting would be to those who profit by the unearned increment of values.

Equalization of the costs of power and of transportation tends to foster the small industries on which local prosperity depends, and this is greatly aided by the transmission of power. And besides calling into action unused water powers, there is an immense possibility of usefulness in the generation and transmission of power from low-grade fuel. Comparatively little is known of the world's resources in inferior coal, lignite, and peat, because the transportation charges have discouraged investigation; but there is good reason to believe that a very large store of energy exists in these unprepossessing forms.

There have been many propositions looking to the electrical transmission of this energy, but for one reason or another very little has practically been done. The growing demand for fuel is bound ere long to push up prices far enough to encourage power transmission from cheap coal, and it very probably may become one of the important factors in the general supply of power.

Up to the present time, however, the utilization of natural powers even has not gone far enough to make a material change in the rate of increase in the fuel demand, so that the great functions of power transmission are largely in the future, in spite of the rapid growth of the art in the last decade. The lesser and secondary effects of power transmission are already much in evidence, in the increasing application of motors to various industrial purposes. Here the effect is seen directly in the saving of labor, and indirectly in the improvement of output due to greater facility in various ways. It seems, for example, fairly well demonstrated that motor driving in textile factories not only reduces expenses by cutting down the net cost of power per machine, but also tends through preservation and accurate adjustment of the most economical speed to enlarge the output per machine. The same tendency appears in print works and in paper mills, and is still more strongly evident in machine shops and engineering works. The modern tendency in these latter cases is to push the output, so as to turn over the investment in plant as rapidly as

possible. A planer, for instance, will within its useful life turn off a certain number of tons of chips and it is economy to do this work rapidly. For each operation there is some speed of maximum economy, and one of the most important features of electrical machine driving is the ease with which this speed, if known, can be reached and maintained. This consideration also affects the cost of a given operation in labor, although it does not imply labor saving in quite the same sense as would be evident in changing from hand work to machine work, or in the use of portable motor-driven machine tools.

To the same category as these mechanical uses of electric power belong a group of electrical labor-saving processes, like electrical welding, electrical annealing, and electrical heating for various industrial processes. No single device of this sort is in such extended use as to give it commanding prominence, yet the class as a whole is a large one, responsible for great total gains in the cost of labor, and the number is very rapidly increasing.

Of a far larger importance are some of the striking electrical processes which belong properly to the domain of electrochemistry. The aluminium industry has already risen to large proportions, and the electrolytic preparation of the metal in the electric furnace has quite superseded all other processes. Carborundum, and calcic carbide, the basis of the acetylene light, are also among the chief products of the electric furnace, although the making on a small scale of rubies and diamonds discloses interesting possibilities. Still more sensational is the fixation of atmospheric nitrogen by electrical means, which, while it can hardly yet take rank as a commercial method of preparing nitric acid and nitrates, gives promise of future usefulness and is particularly important because the world's store of nitrates, as a practical mining proposition, is being depleted rather rapidly and its recuperation by organic processes is very slow. On the whole electrochemistry is today the branch of applied electricity in which the most startling developments may reasonably be expected. And these developments are likely to affect profoundly the world's industries.

Late discoveries like the X rays and wireless telegraphy are probably to be of high value to civilization, but they cannot yet claim great industrial importance. The electrical work of the last half-century has told for much in the world's welfare, and will count more rather than less as the years go by. Its relation to the fundamentals of human industry and civilization has been up to the present less far-reaching than its contribution to the complexity of that civilization. In another century its basic value will be better appreciated.

EDITORIAL COMMENT

THERE are some elements of life so all-pervading that through very familiarity we become unconscious of their presence. It is only by the negative method of imagining them away that we find how widely and deeply they are built into our civilization. Thus, as Mr. Hunt effectively says in our leading article "it is bewildering to try to realize that which *would not have taken place* in human progress," had it not been for Bessemer steel.

So it is above all with labor-saving machinery. Taken in its fullest meaning, there is no act of manufacture, no stroke of construction, no detail even of household work, in which at some stage labor-saving machinery does not play a vital part. Sometimes we stop for a moment before a mighty expression such as the Forth Bridge or the 40,000 horse power of a giant liner, and point to it as marking the progress of the age; but every nail that is driven—every needle in the housewife's work basket—every kettle on the range in the workman's cottage—is equally an expression of the stored skill of generation after generation of inventors—metallurgists, mechanicians, engineers. It is the embodied thought of centuries of genius which lightens the toil and betters the life conditions of the living race.

In so vast a domain, the problem is to choose a path that shall give any sufficient idea of the whole. It must be done, if at all, by centering our attention upon the great facts and principles which underlie—by outlining the principal departments and tracing their typical expression—and by studying representative examples which bear the characteristics common to the group. Even this far exceeds the bounds which necessity fixes for a single magazine. This first "Labor-Saving Number" of THE ENGINEERING MAGAZINE must therefore be taken as part only of the proposed review. It is the opening section of a three-fold group. The present issue deals with the foundation of the subject—the use of power to relieve manual labor. It will be followed shortly by two other numbers dealing with two other great phases—"Labor-Saving in Industrial Management," and "Labor-Saving by Mechanical Transport." And all three outline a field and trace a policy which is defined and filled in, in its details and special applications, consistently and constantly, in every regular issue of the Magazine.

* * *

THE lapse of time between the introduction and the perfection of modern inventions seems greatly accelerated over the rate at which some of the great improvements of past centuries were developed. In the other pages of this issue the story of the long years of toil and discouragement which marked the work of many inventors is told; but while these sheets were on the press engineers and scientists were celebrating with the inventor of the incandescent electric lamp the twenty-fifth anniversary of its production. The quarter-century of life which Mr. Edison's invention has covered, and in the

greater part of which it has been in full commercial operation, is evidence of the promptness with which modern inventions are exploited and adopted.

The Edison banquet, given in New York by the American Institute of Electrical Engineers, celebrating at the same time the fifty-seventh anniversary of Mr. Edison's birth and the twenty-fifth year of existence of the incandescent lamp, was a notable occasion in the history of applied science. Not only was the room brilliant with the glowing bulbs themselves, but there were also present other examples of the inventive skill of the guest of the feast: the quadruplex telegraph, the gold-stock ticker, the phonograph, models of many ingenious applications of science to industry, and all the developments of a single active life of a man yet in his prime, these rendered the occasion most noteworthy.

* * *

As in the case of the John Fritz dinner of two years ago, the Edison banquet was made the occasion of the foundation of a medal, and most appropriately, the Edison medal is to be awarded annually to the student in electrical engineering whose thesis or recorded research shall be deemed most worthy of honor. No better comment can be made upon this noteworthy foundation than that of Mr. Edison himself, as contained in the message telegraphed by himself from his place at the high table to a receiver in the hall:

> "This medal is founded to encourage young men to devote their best thought and work to electrical development. I rejoice in this stimulus to harder study. Better trained and educated than were we pioneers of the times before every college and university had its electrical course, these coming men of the future should, and I believe will, carry forward to triumphs and arts heretofore undreamed of, the principles and applications of electricity to which I have tried humbly to devote my life and energies from the hour my hand first touched the key."

Among the many messages of congratulation received at the banquet may be mentioned those from the President of the United States, from the Lord Chief Justice of England, from Lord Kelvin, from Marconi, from Mascart, Kapp, Carnegie, and others too many to enumerate here, and throughout them all the note was that set by the President, who said:

"I congratulate you as one of the Americans to whom America owes much, as one of the men whose life work has tended to give America no small portion of its present position in the international world."

* * *

WITH the ratification of the Panama Treaty the last uncertainty as to the choice of route for the Isthmian waterway disappears. Eight years ago, when THE ENGINEERING MAGAZINE took up the question, the country seemed hopelessly committed to the Nicaragua project. From that mischance, wise counsel and wide enlightenment have saved us. It is the pride of THE ENGINEERING MAGAZINE that these pages have been the medium through which the very greatest of the thinkers and workers upon the problem have addressed the country, and moulded public opinion to a decision in accord with common sense and sound practical judgment.

The successful, prompt, and economical completion of the work now rests with the Commission. As is their wisdom, so will the result be. The selection of Admiral Walker was natural, logical, and fitting, but not all the appointments are so adequate. It is to be most earnestly hoped that the Commission will be supplemented by a chief engineer whose tried experience and proved success in the conduct of great enterprises of this peculiar kind will give the country a sense of assurance upon which it can confidently rest.

REVIEW OF THE ENGINEERING PRESS.
"THE WORLD IS ITS FIELD"

THE PRODUCTION OF RADIUM.

SOURCES OF RADIOACTIVE MATERIAL AND METHODS OF EXTRACTION OF RADIUM COMPOUNDS OF HIGH ACTIVITY.

Revue Générale des Sciences—Le Génie Civil.

ALTHOUGH much has been written about the curious properties of radium and its compounds, comparatively little information has been made public concerning the preparation of the substance at present attracting so much attention. For this reason the papers of M. Debierne, in the *Revue Générale des Sciences,* and of M. Danne, in *Le Génie Civil* are of interest at the present time, containing, as they do, technical descriptions of the processes involved in the extraction of radioactive substances from the ore in which they are contained.

In order to follow the methods employed, which involve rather great patience and care than any especial appliances or materials, a few words may be said as to the manner in which the existence of radium was discovered. In 1896 M. Becquerel discovered that uranium and its compounds possessed the property of emitting, spontaneously and continuously, although feebly, rays which were capable of acting upon photographic plates, of ionizing gases and rendering them conductors of electricity, and of passing through opaque bodies. Two years later Madame Curie, in France, and Herr Schmidt, in Germany, found that similar properties were possessed by thorium compounds. In studying these new and curious properties of matter Madame Curie found, using the electrical method of examination, that this property of radioactivity was atomic in its character, that is, it was possessed by all the compounds in direct proportion of the quantity of uranium or thorium present. Upon further examination of the mineral pitchblende, from which uranium is principally obtained, however, it appeared that the raw mineral showed a higher degree of radioactivity than was due to the amount of uranium present. This observation led to a series of investigations, involving a process of elimination, the successive constituents of the pitchblende being removed and the remainder examined for radioactivity. The result was the discovery of a minute quantity of material, highly radioactive, and different from uranium, thorium, or any other known substance. By 1900, after long and tedious experiments along these lines, M. and Mme. Curie succeeded in proving the existence of two new elements, a million times more active than uranium; polonium, a substance similar to bismuth, and radium, a material similar to barium. Later M. Debierne has added to these a third radioactive substance, called actinium, and belonging to the group of rare earths.

The radium produced by the Curies has all been extracted from pitchblende brought from Joachimsthal, in Bohemia, and the details of the process are as follows: In the first place all the uranium is removed, this being done at the place where the mineral is found, in order to reduce the bulk to be transported. The crushed pitchblende is roasted with carbonate of soda, the product being then lixiviated with hot water to remove the soluble salts of soda, and then treated with dilute sulphuric acid, the resulting solution containing all the uranium.

The insoluble residue, formerly, in the manufacture of uranium, having been thrown away as without value, is now most carefully collected, since it contains the radium, its activity, even at this early stage, being four or five times that of pure uranium. This residue consists principally of sulphates of lead and of calcium, silica, alumina, and oxide of iron. There are also found in lesser or greater quantities, nearly all the metals, including copper, bismuth, zinc, cobalt, manganese, nickel, vanadium, antimony, thallium, niobium, tantalum, arsenic, barium, and various rare earths. The radium is distributed through this entire mixture in the form of a sulphate.

The first operation effected upon this residue is a treatment with concentrated hydrochloric acid. The material is strongly affected, a portion passing into solution. This solution contains the polonium and actinium, the first being precipitated by sulphuretted hydrogen, while the latter is found in the hydrates precipitated by ammonia. The radium remains in the insoluble portion, which is first washed with water and then treated with a boiling concentrated solution of carbonate of soda, this operation converting into carbonates the sulphates not attacked by the preceding reaction. The material is again washed very thoroughly with water and treated with dilute hydrochloric acid free from sulphuric acid. The solution contains the radium, together with small portions of polonium and actinium. This is filtered and precipitated with sulphuric acid, giving radioactive sulphate of barium, containing also calcium, lead and iron, together with traces of actinium. A metric ton of residue contains from 10 to 20 kilogrammes of these crude sulphates, having an activity of 30 to 60 times that of pure uranium, this latter having been taken as the standard of comparison of radioactivity.

It is now necessary to purify these sulphates. They are first boiled with a concentrated solution of carbonate of soda, and the carbonates thus obtained are converted into chlorides. The chlorides are then evaporated to dryness and treated with pure concentrated hydrochloric acid. The calcium chloride is almost completely dissolved, while the radioactive barium chloride remains insoluble. The solution contains, therefore, the lime, with a very small proportion of the radium. It may be precipitated by sulphuric acid and reworked with a succeeding operation. The radioactive barium chloride is redissolved in water, and again precipitated by carbonate of soda. The washed carbonates are then treated with hydrobromic acid in order to convert them into bromides.

After this long series of operations there is obtained, from a ton of the original material, from 8 to 10 kilogrammes of radioactive bromide of barium, having an activity of about 60 times that of pure uranium. This bromide is now ready for fractional separation. The bromides are dissolved in distilled water, the solution being brought by boiling to the point of saturation. It is then permitted to crystallize in a covered capsule, there being found fine crystals in the bottom of the capsule, from which the liquid may be removed by decantation. These crystals are found to possess about five times the activity of the bromide in solution. The material is thus divided into two portions, upon which the identical operation is repeated. This gives four new portions, which are further treated, the liquid from the stronger crystals being added to the second set of crystals, these portions having about the same degree of activity. There are thus obtained three portions, which are again subjected to a similar treatment. After each series of operations the saturated solution taken from one portion is added to the crystals of the following, there thus being a double series in progress, one continually increasing in strength and the other growing weaker. In this way various radium compounds, such as the bromide, chloride and nitrate, have been produced, of varying degrees of activity.

Radium bromide has been obtained with an activity of about one million times that of metallic uranium, and it and all the other salts of radium are white in color when first prepared, becoming gradually yellowish and even violet in time. They all emit light in the darkness, especially when dried by heat. Owing to the tendency of the chloride and bromide to absorb moisture from the atmosphere they are kept in sealed tubes.

M. Danne gives some interesting details of the apparatus employed in examining the

activity of various salts of radium, and discusses the spectroscopic investigations which have been made, besides proceeding to examine the various phenomena which have been observed, but these are, for the most part fairly well known, and we have therefore abstracted principally the details of the preparation of the material itself. By far the most important researches which are now to be desired are those for the discovery of additional sources of supply of the material to which the methods may be applied, and in view of the great value of the new element there is every reason to believe that the search will be continued vigorously in all parts of the world.

THE INFLUENCE OF ENGINEERING EDUCATION.

TECHNICAL EDUCATION IN RELATION TO THE WORK OF THE UNIVERSITIES OF OXFORD AND CAMBRIDGE.

Dr. John Perry—Nature.

IN the course of an address delivered recently by Dr. John Perry before the Ashmolean Natural History Society of Oxfordshire and the Oxford Mathematical Society and published in a recent issue of *Nature,* some very interesting points bearing upon the broad character of modern technical education were brought out, and in view of the fact that both in England and the United States there still exists a tendency to consider a scientific training as rather opposed to liberal culture some abstract of this inspiring address is appropriate at this time.

Speaking at Oxford, before Oxford men, and with a full appreciation of all that the education given by the great universities has done for England, Dr. Perry does not hesitate to say what he thinks of the unfitness of present methods for present needs. Taking Oxford as representing the general character of the work of both universities, he shows that practically all the men who form the great governing class of Great Britain are either educated at Oxford or Cambridge, or have been trained under the influence of Oxford methods.

"When, at an age of from twenty-one to twenty-four a young man enters Parliament or diplomacy, or any of the reserved parts of our public services, his character is formed; all his ways of thinking and his prejudices are on the models most revered in Oxford. His early youth has been influenced by Oxford of the past, his undergraduate ways have influenced and been influenced by Oxford of the present, and his prejudices, kept strong by loving memories, exercise an influence against all changes in Oxford for the future."

Dr. Perry does not fail to see the beauty in the Oxford method of education, especially for the limited number of Oxford men who are real students. For them it is the ideal place for one of the most wonderful educations ever known, a place where they meet every day the great scholars of their age who are also students, where they can obtain the highest kind of an education, that which comes from contact with inspiring and enthusiastic teachers.

At the same time this education is not the education which can fit men for the conduct of affairs at the present day. Oxford was in the forefront of the renaissance movement, and in that brilliant time she did not think it beneath her to take up with the great movement of the day. To-day she is retreating back even from the conceptions of the renaissance and becoming more and more mediæval, and the men she is producing are showing themselves correspondingly unfit to cope with present problems. By far the greater number of Oxford men are not students in the sense of searching out the new truths or fathoming the old ones. Dr. Perry does not quote, although he doubtless well remembers Dean Swift's sarcastic saying about Oxford. "Oxford," said Swift, "is a learned place; because a great many men have taken learning there, and no one was ever known to take any away, and so it has accumulated."

"The world now to be governed is getting more and more complex. Man is utilising the energies of nature in thousands of ways unknown to the ancients. Common people are all getting educated. Where

the ancients wondered and trembled, we understand and give orders to nature. The average unit of any population was compelled to be what we now call an unskilled labourer.

"Now our labour is becoming more and more skilled. Are you aware that from one ton of coal there is as much energy, as much actual work, as may be done by forty thousand good labourers in a ten hours' day? Our best steam engines utilise only one-tenth of this energy at the present time. But even now we know that the cost of the most unskilled work done by man is one thousand times the cost of the same work wherever it may be done by the best steam engines. One fact of this kind properly considered is worth many long essays about the effect of the engineer in altering all the character of our civilisation. It is labour that is the true standard of wealth. The steam engine has added incalculably to the wealth of the world. We forget that man is no longer needed for unskilled labour, so that when we use unskilled labour we are using the materials which God has given us in the most inefficient manner possible. Furthermore, it becomes sweated labour, it unduly taxes skilled labour, it starves invention, and it brings up base, ill-fed families."

If the rulers of Great Britain, the men who are to make and to execute her laws are to continue to be the product of her universities it is time to consider the kind of a preparation which these universities are giving them. As Dr. Perry well says: "It is a curious kind of culture which scorns the lessons of history, the study of man in his relations to nature, the study of the enormous new forces which are now affecting the relations of nations to one another. How is a boy to reason about things unknown to him. In the nursery he got mental training through everything he saw, everything he clutched. Oxford took charge of him scholastically at the age of seven, and from that time onward his higher mental powers ceased to grow. His mental equipment suggests the item for bread in Falstaff's famous tavern account."

"And he becomes a ruler of this great nation, his duty during war and peace being that of a scientific administrator. Times of actual war are few and short; in those times the people and property of unprepared nations are destroyed with a rapidity never known in the past. In all old times England was unprepared for war, but this did not then so much matter; in future the nation has not prepared for possible war, by the exercise of the highest scientific faculty, will certainly be destroyed.

"Also the war between nations is quite intense in times of peace. The rulers of nations have to take care that their laws do not destroy industries, that they develop the right sort of education of the people; that the people shall be so educated as to become resourceful, full of initiative and invention, capable of learning from experience, people of character. Again, if our rulers set a fashion of gibing at scientific things, at technical education, for example, through ignorance, it is not unimportant to know that the complete loss of trades like the coal tar industries may be more serious evils than the loss of several campaigns in war used to be. If the Prime Minister, or any other minister, gives an important post to a non-scientific man, it may not be harmful, but sometimes it may be very harmful indeed; it may lead to the appointment of many unscientific men or the disgrace of the scientific men already engaged in some department where science is all important. But the evil is very much more far reaching than one can describe in words. Want of science in the rulers means neglect of scientific education and method throughout the whole country."

Although England has done her share in the development of applied science, she has by no means kept pace with France, Germany, or the United States in the development of her educational institutions.

"It is not the schoolmasters, it is the engineers who have been educating England. The engineer is always thinking of utility, of the value of time, of the fact that a man has only one life in which to do what good it is possible for him to do. So he reads novels and poetry and history; he enjoys painting and music; he travels and sees other people, other nations and their monuments. He cultivates and exercises the whole of his mental and emotional machinery so that he may become more perfect as a student of what Goethe called the living mantle of God.

"Everybody speaks of how the engineer has created what is called modern civilisation, has given luxuries of all kinds to the poorest people, has provided engines to do all the slave labour of the world, has given leisure and freedom from drudgery, and chances of refinement and high thought and high emotion to the thousands instead of units. But few seem to see that the engineer is educating the imagination and poetic faculty of England. Every unit of the population is becoming familiar with scientific ideas, for he can hardly take a step without becoming acquainted with romantic steam engines and electromotors, with telegraphs and telephones and steamships, with drainage and water-works, with railways, electric tramways and motor-cars. Every shop window is filled with the products of engineering enterprise. It is getting to be rather difficult for people to have any belief in evil spirits and witchcraft, and this is probably the most enormous intellectual stride that the great body of the human race has ever made in any half-century. It has been made in spite of the persistent opposition of Oxford."

As a matter of fact the whole movement for technical education has been hated and even feared at Oxford, and yet it has progressed continually, and that largely by the efforts of a few Oxford men who have ventured to break through the limitations which their Oxford training imposed upon them.

"It is not only that Oxford keeps aloof from technical education, but she keeps aloof from the very much greater thing of which this movement is only a symptom, namely, the phenomenon that trade and manufacture are no longer left to themselves as they used to be; they are being organised on scientific lines in all countries. She has always ostentatiously held herself aloof from manufactures and commerce. It is almost incomprehensible that a university aiming at breadth of culture should scorn those things which keep England in her high position, give value to the real estate on which Oxford's own revenues depend, and differentiate Oxford from Beyrout."

The influence of Oxford was at one time supreme over England, and it is still enormous, but it is a matter for Oxford and Oxford men to decide how much longer that influence may continue, and whether it shall work for good or for harm.

THE SPECIFIC HEAT OF STEAM.

DETERMINATIONS OF THE RELATION OF THE SPECIFIC HEAT OF SUPERHEATED STEAM TO THE TEMPERATURE

Verein Deutscher Ingenieure.

WITH the increasing applications of superheated steam to practical service there has arisen of late a demand for more accurate data for use in the necessary computations. The investigations of Regnault, made more than 50 years ago have stood the test of continual practical application marvellously well, and it is only when the limits within which he worked are being exceeded that there has been found any occasion to add to his results. It is now becoming desirable that the relations of pressure, temperature, and volume of steam should be experimentally determined for pressures above 400 pounds per square inch, while experience with superheated steam has convinced engineers that the value of the specific heat of steam, (0.48) given by him, is too low for the high temperatures now under consideration.

In recent issues of the *Zeitschrift des Vereines Deutscher Ingenieure* there are papers by Dr. A. Griessmann upon the total heat of superheated steam, followed by a study of the question of the true value of the specific heat by Professor Weyrauch, these together furnishing the latest experimental and theoretical discussions of this important question. From the nature of the subject it is impracticable to give here more than a general idea of the results which have been obtained, referring the interested reader to the original papers for the diagrams, and for the mathematical analysis.

Dr. Griessmann examines the experiments made in England by Grindley, and compares them with a series conducted

with much care by himself. Both series of tests show that the specific heat increases with the temperature, but the experiments of Griessmann indicate that the rate of increase is less rapid than given by the results of Grindley, and since the tests of the latter at the higher temperature show a tendency to approach those of Griessman, it may be that a closer accord would follow a renewed investigation.

Thus, according to Dr. Griessmann the specific heat at 130° C. is about 0.48, while at 150° C. it is 0.55, and at 160° C. it reaches 0.60; following very nearly a straight line law. Grindley, however, gives a value of 0.52 for 130° C., and reaches 0.63 for a temperature of 150° C. In view of the fact that the experiments of Griessmann are more numerous than those of Grindley, and that they show a substantial agreement with each other, it is probable that his values are more nearly correct than the higher ones.

Professor Weyrauch is inclined to accept still lower values, taking, in his computations, the formula of Regnault with the constants derived by Hirn: $c = 0.43 + 0.000378\ t$, in which c is the specific heat at constant pressure, and t is the temperature in degrees centigrade. This gives, for a temperature of 160° C. a value for c of 0.49, which is so much below either Grindley or Griessmann as to be received with hesitation. Although Griessmann gives no formula to represent his experiments, his results are very closely reproduced by the expression: $c = 0.375 + 0.00375\ (t - 100)$ in which the values of c and t are the same as before, the expression $(t - 100)$ corresponding to the excess in temperature of the steam above the boiling point.

These later results agree very fairly with those deduced by Professor Bach several years ago, and also with the theoretical investigations of M. Delaporte, reviewed in these columns last month.

With this substantial agreement between experiment and theory this important question must be allowed to rest until further investigations add to the fundamental data upon which a rational formula may be based.

MECHANICAL ROAD TRACTION.

THE RENARD SYSTEM OF AUTOMOBILE TRAINS WITH MULTIPLE PROPULSION FOR THE TRANSPORT OF MERCHANDISE OVER HIGHWAYS.

Le Génie Civil.

ALTHOUGH by far the greater portion of the attention which has been given to motor vehicles has been directed to the production of pleasure, racing, and touring automobiles, this phase of the subject must necessarily subside to a certain extent and the more practical problems of transport be treated scientifically. Automobile trucks, lurries, delivery wagons, and the like have been designed, and many of these have proved themselves efficient and convenient, but their limited capacity has prevented their use for the cheap transport of merchandise in quantity over considerable distances. Attempts have been made to provide a powerful machine, hauling several trailers, and although some success has been attained in France in this way by Scotte, the difficulty in controlling and manœuvring such trains on the highway has prevented their general use.

A modification of the train system is that which has been devised by Col. Renard, and from a description of his system in a paper by Col. Espitallier, in a recent issue of *Le Génie Civil* some account of the method is taken.

The principle involved in the system of Col. Renard is that of making each member of the train self-propelling, the motor vehicle at the head being simply a portable generating station from which the energy is distributed to all the vehicles. With this is included an automatic system of steering, by means of which the members of the train all track the same, in such a manner that if the motor vehicle is run in sand all the other vehicles of the train will pass in its tracks, regardless of the curvature or irregularity of the course.

The principle employed in the Renard system is by no means new, having been employed for railway traction by W. H. James in England as long ago as 1823. Its use on

highways, however, is the main feature under present consideration, and for this purpose it possesses many advantages. Briefly the method consists in the use of a continuous line of shafting, driven by the motor on the power vehicle, the trailers being connected by short sections of shaft with double universal joints. By using the well-known arrangement of two universal joints the angular speed variation is obviated, and the rotation of the motor is transferred smoothly to each vehicle. The main line of shafting runs through the entire train, which may contain as many vehicles as may be necessary, each taking its power from the shaft by bevel gears, and all thus being propelled at the same speed.

Each vehicle has its front wheels fitted with the Ackermann arrangement of steering levers, and these levers have a short tongue forming the connection to the preceding car. As each car is deviated from its path it turns the connection to the next, this turning the steering wheels to the proper angle, and causing all the cars in the train to follow the path of the forward motor car.

The arrangement forms a combination of which the tractive power is limited only by the power of the motor, and all the difficulties involved in the haulage of a train by the adhesion of a few wheels to the road are avoided. If one vehicle encounters a bad place in the road the adhesion of the remaining cars will generally be found sufficient to pull it through, while the combined tractive power of the whole train enables grades to be surmounted which would be altogether impracticable for a single traction engine and train.

The rigidity which might otherwise be found objectionable in such a mechanical connection through an entire train is obviated by the use of spring compensating devices placed in the connection between the main shaft and the driven axles. In the trains with which recent experiments have been made in France this spring connection is placed in the hub of each driven wheel, in the form of a spiral band spring, making an elastic connection between the wheel and its shaft; a plan which has been found to work well in actual service.

Experiments with trains of the Renard type, using steam and gasoline motor vehicles, have shown that trains of eight to ten vehicles can be propelled along highways at speeds of 4 to 18 kilometres per hour, according to the grades, while trains with four cars make speeds of 8 to 36 kilometres, the motor itself being capable of a speed of 72 kilometres. In all cases the trains have showed themselves to be under perfect control, turns of short radius being made with ease, and grades as steep as 10 per cent. being surmounted.

The practical applications of this system will be seen to be numerous and important. As originally planned by Col. Renard, it is intended to provide mechanical propulsion for army trains, and for this purpose it offers numerous advantages. Heavy military automobiles are necessary of limited use in difficult country, while their carrying capacity is limited. Experience with ordinary traction engines hauling wagon trains has been discouraging, because of the difficulty in controlling the train, and the insufficient adhesion of the single machine. With a multiple driven train the main power vehicle need not be of excessive weight, while the distribution of the weight and power of the whole over an extended length enables headway to be made where it would otherwise be impossible.

Apart from the applications of the method to military purposes it is quite possible that such a system of merchandise transport upon ordinary highways may prove a valuable auxiliary to the work of steam railways. There are many districts which could be brought into connection with railway stations and thus developed if feeder lines of road transport were established, and the ability to make up trains along the road, and deliver these to the neighboring railway might build up important additions to the traffic of a system.

In this connection it is interesting to note that a similar system of highway train transport has been developed in the United States. The Gibbs system, however, operates by the use of electric instead of mechanical transmission between the vehicles, with separate electric motors on each vehicle, a gasoline engine and a dynamo being carried on the tractor. There is undoubted room for both systems, and the success of either depends mainly upon the provision of suitable roads to permit the use of mechanical traction with reasonable convenience.

THE SINGLE-PHASE RAILWAY MOTOR.

THE LATEST DEVELOPMENTS OF THE ALTERNATING-CURRENT ELECTRIC MOTOR FOR RAILWAY SERVICE.

American Institute of Electrical Engineers.

IN the tremendous development of electric railways, the direct-current motor has been almost universally employed, and the close study and hard work that have been given to it have resulted in the evolution of a machine which is admirably adapted to its environment. It is efficient, simple, easily regulated, and has been brought down to small compass and weight. In itself and in its controlling apparatus it leaves little to be reasonably desired, and as long as electric railways were confined within a limited area there was small demand for anything better.

But with the growth of interurban railways and the application of electricity to the operation of long-distance standard roads, the question of the distribution of current has come to the front, and becomes more and more insistent the longer the line. This question has been answered indirectly by transmitting high-tension alternating currents from some power station conveniently situated to rotary-converter substations and there converting them to direct current of moderate voltage for the motors.

Another solution of the problem has been by the use of polyphase motors, fed directly, or through a transformer on the car, with current from the line. Among the notable examples of this class of road are the Valtellina railway in Italy and that between Burgdorf and Thun in Switzerland.

The polyphase system, however, has several inherent disadvantages, among which are the necessity for having three line conductors, or two and the return through rails and ground, the inefficient operation of the motors except at certain critical speeds, and the complicated controlling apparatus, involving liquid rheostats and other troublesome parts.

All these considerations have forced upon electrical engineers the necessity of designing a single-phase alternating-current motor which shall meet the modern requirements of railway work. Such a motor must be able to start under a heavy load with a reasonable consumption of energy, and should possess a high efficiency over a wide range of speed. Patient investigation and many trials have shown that the single-phase motors which best fulfill these conditions have commutators on the armature, or rotating member, and are in many respects similar to ordinary direct-current series-wound motors, but with laminated iron in the fields to avoid excessive loss from eddy currents, and with special precautions to prevent sparking at the brushes. The commutator type of single-phase series motor may be divided into two main clases, in one of which the primary current traverses both the field and the armature, and in the other of which the armature forms a secondary circuit, closed upon itself, currents being induced therein by a primary winding which may be part of the field.

Within the past year or so the different kinds of commutator single-phase motors have been developed to the point of commercial usefulness, and at a recent meeting of the American Institute of Electrical Engineers they formed the subject of discussion, one of the types, the so-called repulsion motor, being particularly treated in two papers, one by Mr. Charles P. Steinmetz, on "The Alternating-Current Railway Motor," and the other by Mr. Walter I. Slichter, on "Speed-Torque Characteristics of the Single-Phase Repulsion Motor."

The repulsion motor has what is very much like a regular direct-current armature in an induction-motor field. "The resemblance to the induction motor is carried still further in that there is no electrical connection between the primary and secondary. This makes it possible to wind the primary for a high line voltage, while the voltage of the secondary winding is chosen at such a value as may be commutated satisfactorily, since it is short-circuited on itself through its brushes.

"The motor has the same characteristics as the direct-current series motor; namely, maximum torque at starting, increasing torque with increasing current and decreasing speed, and comparatively constant effi-

ciency through a wide range of speed. The maximum speed of the motor is limited only by the load and impressed voltage, and has no relation to the synchronous speed.

"Owing to the reactance of the motor circuits, the power factor at starting is low and will be so with any alternating-current motor; but in the repulsion motor a low power factor does not mean small torque. On the contrary, the maximum torque occurs simultaneously with the lowest power factor; that is, at starting. The power factor of the repulsion motor rises very rapidly with the speed; it reaches a good value at one-third synchronous speed, and values near to 90 per cent. are obtained over a considerable range of speed. For this reason a large number of poles is not necessary and frequencies of 25, 40, and even 60 cycles may be employed.

"The rotating conductors of the secondary cutting the primary flux, generate a leading electromotive force, which causes a leading current to flow therein and gives the high power factor of the motor. In the plain repulsion motor, this leading current never reaches a value great enough to compensate entirely for the magnetizing and other wattless currents at available speeds, but the phenomenon is utilized to obtain unity power factor in the compensated type by the addition of a second circuit. The inherently good power factor of the repulsion motor makes it possible to use larger clearance between field and armature than is permitted in induction motors, thus greatly increasing its value in railway work where comparatively large air gaps are necessary.

"The efficiency while not so high as in a direct-current motor, is yet very good, reaching values of from 80 to 85 per cent., including gear loss, for sizes ranging from 50 to 200 horse power.

"Commutation at normal speeds is inherently good, owing to the revolving field. As the speed decreases, the current increases rapidly, producing a tendency to spark, but with the reduced voltage of starting the rush of current is limited to values within the range of good commutation, as in the direct current motor.

"At higher speeds, ranging above one-and-a-half times synchronism, the frequency of commutation becomes high and sparking appears."

Mr. Steinmetz called attention to the early work of Rudolph Eickemeyer, of Yonkers, "who was far-sighted enough to realize the absolute necessity of the series-motor characteristic for railway work, and to undertake the development of the single-phase alternating-current series motor.

"As was pointed out by Gisbert Kapp, the power factor of the alternating-current series motor is inherently low, since the same magnetic flux which induces, proportional to the frequency of rotation, the electromotive force of useful work in the armature conductors induces in the field coils an electromotive force of self induction, proportional to the frequency of alternation, thereby giving the armature the same number of turns as the field (which is more than is permissible in good practice, since that requires weak armature and strong field). Even at synchronous speed the electromotive force of rotation of the armature would still only be equal to the electromotive force of self induction of the field; and the power factor, allowing for an additional self-induction of the armature, would be below 70 per cent.

"Eickemeyer solved this difficulty by designing the armature with a number of turns several times greater than the field (24 to 7 in the first motor built), and neutralizing the armature self induction and reaction by a stationary secondary circuit surrounding the armature at right angles electrically to the field circuit, and either shirt-circuited upon itself or energized by the main current in opposite direction to the current in the armature."

Several motors of this type were built and tested, with fair results, but at that time, 1891 and 1892, the high frequencies used in standard practice militated against success.

"Instead of closing the stationary circuit upon itself as secondary circuit and feeding the main current into the rotating armature as primary circuit, mechanically the same results would obviously be obtained by using the stationary circuit as primary energized by the main current and closing the armature upon itself as secondary by short circuiting the brushes and thereby keeping the main current and the line potential away from the armature. This introduces the great advantage of reversing the sign of the uncompensated part of the armature self

induction, so that it is subtractive, which results in an essential improvement of the power factor, especially at low speed.

"This motor, then, consists of a short-circuited armature surrounded by two coils at right angles with each other and connected in series, the one parallel to the effective armature circuit, acting as primary of a transformer to induce the secondary armature current; the other being the field exciting coil. The ratio of turns of these coils is the ratio of effective armature series turns to field turns, as discussed before. Obviously, these two coils can be replaced by one coil at an angle with the position of brushes, and the cotangent of the angle which the axis of this coil makes with the position of the brushes is the above ratio; that is, the smaller this angle the greater is the ratio of armature to field turns; that is, the better the power factor of the motor."

Such a design as this last constitutes Professor Elihu Thomson's repulsion motor.

Mr. Slichter exhibited curve sheets showing the characteristics of some of these repulsion motors. One of the sheets gave curves "taken from tests on a 60-horsepower, 25-cycle, 500-volt motor, which show the rapidly rising efficiency and power factor and the large torque at starting. The starting torque is 2,300 foot pounds, with an input of 325 amperes, and the normal torque during acceleration, 450 foot pounds at 750 revolutions and 125 amperes. Thus the starting torque is 5 times normal and the starting current 2.6 times normal; or the torque per ampere at starting is 1.92 times what it is at normal speed, should occasion demand the full starting capacity of the motor.

"This gives an idea of the steep speed-characteristics of the motor, which are even better shown in another sheet comparing the speed and torque curves of a repulsion motor and a standard direct-current series railway motor. This shows that the torque increases more rapidly with increasing current in the repulsion motor than in the direct-current; and, conversely, that the speed of the repulsion motor increases more rapidly with decreasing current than in the direct-current motor. Efficiency, including gear loss, is 84.5 per cent. at the maximum for the alternating-current motor.

"The characteristics show the repulsion motor to be admirably adapted for acceleration work, the efficiency of acceleration being higher than in direct-current work, due to the possibility of obtaining fractional electromotive forces with alternating currents without introducing the dead resistance losses of the direct-current system of control."

This is shown on a third sheet, which gives the acceleration curves from a test of a 25-ton car equipped with two 60-horsepower repulsion motors, and corresponding curves calculated for a direct-current equipment.

"The gearing is chosen for the same free running speed, 33 miles per hour, the same average acceleration, and the same distance covered in sixty seconds. For the direct-current motor the curve of kilowatts input, miles per hour, and miles traveled, are given as calculated; and for the alternating-current motor, the kilovolt-ampere input, kilowatt input, miles per hour, and miles traveled, from test.

"The repulsion motor remains on the controller only 16 seconds and the direct-current motor 25 seconds. The maximum power taken by the direct-current motor is 70 kilowatts and by the repulsion motor 61 kilowatts or 67 kilovolt-amperes. At the end of 25 seconds, the total kilowatt-hour input in the two cases is .375 for the direct-current and .30 for the alternating-current car. At the end of 60 seconds both cars have covered a distance of .039 mile and have reached practically the same speed of 32.5 miles per hour, the kilowatt-hour input being .72 for the direct-current and .685 for the alternating-current car.

"By comparing the areas of the kilowatt curves in the two cases the gain, or rather the saving, by the use of the alternating current is readily seen. It is also worthy of note that the volt-ampere input of the alternating-current motor is least at starting; that is, the line current is least. As this is the time at which the power factor is lowest, it is seen that the effect of the low power factor on the regulation of the system is much modified by the small value of the current.

"A fourth curve sheet shows the calculated characteristics of a 175-horse-power railway repulsion motor having an air gap of .15 inch and wound for 1,500 volts and 25

cycles. The efficiency, including gear loss, is 85 per cent. at the maximum, and the power factor is 93. Such a motor is designed for heavy, slow-speed locomotive work, which is probably one of the most promising fields for the alternating-current motor. It is readily seen how well it is adapted for freight haulage by the fact that the efficiency of 85 per cent. is attained at a speed as low as 500 revolutions, thus permitting a speed of 12 to 15 miles per hour, with a good gear reduction."

In answer to questions, Mr. Slichter said that so far the largest motors which his company had placed on standard car trucks with 36-inch wheels did not exceed 100 horse power, but it is understood that progress in this direction, as in others, is being made all the time; and in the course of the discussion Mr. B. G. Lamme stated that he had been able to instal 150-horse-power single-phase motors on trucks with 36-inch wheels, and had even been able to squeeze them onto 33-inch wheel trucks, and that he expected soon to do the same with 200-horse-power motors.

The discussion also brought out the statements that the single-phase motors at present weigh a little more than the direct-current machines of the same power, but that there is every expectation that the weight of the alternating-current motor will be reduced when it receives as much general attention as has been given to the direct-current types. The weight of the controlling apparatus for both kinds of motor is said to be about the same.

From all the facts elicited at the meeting under review, and from other information of work along similar lines in Europe, it may safely be stated that the long-desired single-phase railway motor has arrived.

THE HEAT TREATMENT OF STEEL.

SIXTH REPORT OF THE ALLOYS RESEARCH COMMITTEE UPON THE BEHAVIOUR OF ALLOYS OF CARBON AND IRON.

Institution of Mechanical Engineers.

AMONG the valuable investigations conducted by the Institution of Mechanical Engineers the successive reports upon alloys have held a high place, and the appearance of the sixth, and last of the present series demands careful attention and review. In some sense these reports form a memorial to the late Sir W. C. Roberts-Austen, since the important share which he took in the investigations upon which they are based has been well known, and the fact that the present report is the only posthumous work of his rendered its appearance an occasion for some worthy tributes to his memory. The report, although blocked out by Sir William Roberts-Austen, is practically the work of Professor William Gowland, assisted by Mr. Merrett, Mr. Harbord, and others, to whom full credit should be given.

The sixth report practically forms a supplement to the fifth report, continuing the subject of steel, considered as an alloy of iron and carbon and of other minor constituents, and is devoted entirely to the effects of heat treatment upon test specimens of different chemical compositions. The tests were made upon steel of eight different compositions, each variety being subjected to twenty different kinds of heat treatment, thus giving 160 variations, the effects being examined by mechanical and metallographical examination, this plan being devised to enable comparative data to be secured for future study.

In his introduction Sir W. Roberts-Austen emphasises the vital importance of the consideration of the phenomenon of allotropy in connection with the study of the properties of steel. The allotropic changes in the iron itself are all important factors in determining the relations between iron and carbon which are involved in the characteristic capacity of steel for being hardened and tempered. The question of annealing is included in the work discussed in the report, the definition of annealing adopted being that of Sauveur as the operation of rendering the quenched metal "as soft, tough, and ductile as possible, by decreasing the elastic limit and tensile strength only by such abnormal increments as were acquired by hardening and cold working." The annealing of the test specimens under

consideration was effected by maintaining the steel at a temperature ranging between 625° C. and 1,100° C., followed by a more or less prolonged cooling.

In connection with the investigations upon annealing a portion of the report is devoted to a study of the effects of "soaking," or the exposure to heat for a prolonged period. This has been effected by examining the properties of specimens which have been heated to definite temperatures for twelve hours, with the result of showing very definitely the changes which this operation is capable of effecting.

The third portion of the report is devoted to a discussion of experiments upon hardening, this effect being produced by causing a portion of iron carbide to be dissolved in the iron and a reversion to the soft condition being prevented by the rapid abstraction of heat.

The report is therefore divided into three parts, treating successively of annealing, soaking, and hardening, each of these being discussed with the aid of tables diagrams, and microphotographs. Its voluminous character prevents anything but a general review of the results here, while reference to the original will enable detailed information to be gathered from the tables and other records. The report is a noteworthy example of the extent to which the new science of metallography is coming into practical service, and the microphotographs are very fine examples of the work of the microscope and the camera.

One of the most important results of the annealing experiments is the confirmation which they give of the effect of moderate temperatures, a heat of 620° C. having a perceptible effect in increasing the elongation. The continuation of the annealing experiments show that a temperature of about 900° C. gives the best results, the bars heated to this temperature for half an hour showing practically a complete solution of the various constituents, permitting rearrangements to take place according to the rate of cooling.

Under these conditions the maximum strength is obtained, as well as a material increase in elongation under test, while if this temperature is greatly exceeded the material is liable to become burnt.

Passing to the soaking experiments, in which a period of twelve hours instead of half an hour was given to the heating of the specimens, it appears that the increase in the duration of application of heat has a marked influence upon the material. The effect upon bars soaked at a temperature of 620° C. was to reduce both the breaking strength and the elastic limit, but to increase the elongation very materially over that of bars heated only half an hour. At the higher temperatures no material difference was shown for the soaked bars over the annealed specimens, except for the bars containing 1.3 per cent. of carbon, which, when soaked for twelve hours, showed a greatly increased degree of elongation.

The most important conclusion drawn from the results of the soaking experiments is the possible availability of the process for the production of metal suitable for the construction of gun tubes.

The present method of producing large ingots of gun steel is by quenching in oil and subsequent annealing, but with pieces of large size it is but with pieces of large size it is difficult to secure uniformity by this process. By an examination of the experiments, however, it appears that the necessary mechanical properties for the construction of ordnance have been obtained in soaked and slowly cooled low carbon "special" steels. It also appears possible to use an ordinary "soaked" carbon steel for this purpose, so that the researches of the committee in this direction may prove of great value in connection with ordnance construction.

The experiments upon hardening contain results obtained by heating the specimens to temperatures from 720° C. to 1,000° C. and quenching them in various cooling liquids. Since this process is one frequently used in the arts, and one concerning which many discussions have been held, and numerous nostrums advocated, some of the remarks about it are of interest. Within certain limits, the more rapidly the heat is abstracted the more effective will be the hardening. The bath must be large enough to have its temperature but slightly affected during the quenching of the metal, otherwise the hardening will not be uniform. In the tests discussed in the report water was used, and also oil, the results being very fully tabulated and illustrated. The rela-

tion of the hardening temperature to the carbon content and to the general composition is clearly shown, and the results should be of material value in connection with practical operations of this sort.

The whole report is a most valuable contribution to the applied science of engineering, and the Institution is to be congratulated upon the success of the work of the committee which it has appointed and maintained. It is just such work as this which removes "practice" from the domain of empiricism and relieves theory from the imputation of impracticability. When all the fundamental operations and methods of engineering are subjected to such judicial investigation and study the opportunities for quackery in applied science will be vastly diminished, and the progress of civilization correspondingly aided.

ELECTRICAL STATISTICS IN GERMANY.

TABULAR REVIEW OF THE DEVELOPMENT OF CENTRAL ELECTRIC GENERATING STATIONS IN THE GERMAN EMPIRE.

Elektrotechnische Zeitschrift.

IN a recent issue of the *Elektrotechnische Zeitschrift* appears the regular annual review of the growth of the production of electricity in the empire, from which we abstract some data of interest. The report is very complete, the various cities being arranged in alphabetical order, followed by columns giving the population, the electric system employed, kind of motive power, capacity in kilowatts, etc. As in the case of previous reports, the data relate only to generating stations which distribute electrical energy for general public use and for sale, with the exception that some large private plants from which current is delivered to operative departments at a distance are included, these practically constituting central stations as important as some of the public plants. The statistics are brought down to April 1, 1903, and are thus comparable with those for the same period in previous years.

There are at present in Germany 939 electric stations coming within the above classification, to which may be added 95 others in course of construction, some of which are doubtless in operation at this date. Of these 939 stations there are 50 having outputs of more than 2,000 kilowatts, these being distributed among 37 cities, and their total capacity being 271,479 kilowatts. The largest stations are naturally to be found in Berlin, where the Moabit station represents 26,523 kilowatts and the Oberspree station, 25,425 kilowatts. Berlin has also a number of other electric generating stations, the total output being 75,600 kilowatts. The great hydro-electric station at Rheinfelden is credited with 12,600 kilowatts, while Munich, Frankfurt, Hamburg, and the other large cities follow close behind.

In comparison with the previous year a material advance appears. The total number of stations in the report for 1902 was 870, as against 939 for 1903. In 1902 the number of incandescent lamps supplied was 4,200,203 and in 1903 this had risen to 5,050,584; while the number of arc lamps had increased from 192,059 to 218,953.

Although many of the stations included in the list are used for local service there are some which extend their distribution over a wider area. Thus the works at Brühl, near Cologne, delivers current for lighting and power to 66 establishments within a radius of 15 to 20 kilometres, while the Upper Silesian Works supplies current to the entire surrounding manufacturing district. The hydro-electric station at Rheinfelden delivers electrical energy to 46 distinct points, while the Neckar Works supplies 40 establishments.

An important feature in connection with the distribution of electrical energy over an industrial district is found in the application to household manufacturing, the small consumer being able, by reason of convenient available power supply, to compete with the large factories. An example of this phase of the question is seen in the case of the Anrath works near Crefeld, in which the greater part of the current generated is consumed in operating motors of ¼ to ½ horse power for driving the silk ribbon looms in the houses of the independent operatives.

The publication of these statistics affords a most interesting view of the growth of the electrical industry in Germany, and a comparison of the present figures with those of previous years is instructive. Thus in 1894 there were but 148 stations in the empire, and the growth at first was but gradual. By 1899, however, the increase was more rapid, the figure advancing from 489 stations in 1899 to 652 in 1900, and, as already noted, reaching a total of 939 generating stations, exclusive of isolated plants, in 1903. The increase in output, however, has been far greater, since the later stations include the much larger modern plants. Thus the increase in number of stations has been 631 per cent., while the number of incandescent lamps has grown from 493,801 to 5,050,584, or more than 1,000 per cent., and the horse power of motors supplied has increased from 5,635 h. p. in 1894 to 218,953 h. p. in 1903, or nearly 4,000 per cent.!

With the increasing development of the industry there has naturally appeared an increasing difficulty in obtaining full and complete statistics of the various works, but the information is well worth all it costs, and it is to be hoped that the desirability of keeping such a full and complete record will appeal to the producers as well as the consumers of electric current, and also to the manufacturers of electrical machinery, and that full data and information will be freely furnished for the purpose of disseminating reliable data.

GAS ENGINES IN RAILROAD WORK.

APPLICATIONS OF THE INTERNAL-COMBUSTION MOTOR IN RAILWAY SHOPS, YARDS, AND PUMPING STATIONS.

Prof. W. T. Magruder—Central Railway Club.

DIFFERENT kinds of motive power machines have their applications for various purposes, and the influences which control the choice are not those always which are most apparent at first. The claims for the gas engine, or more broadly, for the internal-combustion motor, are generally based on its high economy, but there are other reasons which are sometimes of greater importance. In discussing the use of gas engines in railroad work, Professor W. T. Magruder, in a paper recently presented before the Central Railway Club, examines the various reasons for the extended use of the gas engine in various departments of railway plant, and some abstract of his paper is given as indicating the importance of the subject.

The earliest use of the gas engine in railway service was in connection with pumping stations, especially for isolated points where skilled attention could be given only intermittently. Such engines may be started in the morning by the station agent, or by a track walker, and left running until stopped by an automatic appliance when the tank is filled, or stopped by the same attendant at the end of the day. Using gasoline as fuel such engines have come into extensive use in the central and western states of America, and although primarily introduced for reasons of convenience they have also been found extremely economical.

As Professor Magruder points out, however, such gas-engine pumping plants have been used almost entirely for small installations the opinion prevailing among railroad men that steam is preferable for larger plants. The development of the large gas engine, however, is extending to railway service, and in some instances a gas electric power system has been introduced, the power being transmitted electrically to pumps at a distance.

"If the plant is such a large one that the services of a pumper are constantly needed, then a cheaper fuel than gasoline should be used, and either a suction gas producer or an oil gas producer should be installed. By this means the total cost of operation can be reduced by the difference in the cost per horsepower of the coal used in a boiler, and the coal or oil used in a producer. It is not considered wise to allow the gasoline plant to be without attention for over four or five hours at a time, as the delay to train service by lack of water at the pumping station due to a break-down of the gasoline engine or pump would be more costly to the company than the services of

a pumper for many days. It should be borne in mind, however, that there are certain spare parts which every gasoline pumping station should always have at hand, such as extra battery parts, ignition points, springs and lubricating devices, just as there should be extra or spare parts at a steam pumping plant for use in case of sudden break-downs. Many vexatious and expensive repairs can be prevented by the installation of an engine and pump of high grade. In this, as in many other lines of industry, the machine lowest in first cost is not necessarily the cheapest. A certain number of parts are necessary to every engine or machine, and the builder who saves the purchaser the expense of a few dollars by omitting these parts frequently causes him to spend several times the amount so saved in extra fuel required and in more frequent repairs. On the other hand, the best engine does not necessarily have to have an excessive number of parts, and usually such an engine is liable to easily get out of order. Each part of a gas engine or other machine should have a definite object for its existence, and a definite duty to perform, for which it should be suitable in both strength and material. If continuity of service is desired in a railroad pumping station, it may not be necessary to install an engine such as is required for generating of electricity; but, on the other hand, to install one of the type of engines usually found in the oil fields would be the height of folly, as their construction and finish is usually such that their life is short and directly proportional to their first cost as compared with other engines, while their fuel consumption may be outrageously high. This last is a point of little moment in the case of a pumping engine in the oil fields, using a surplus of fuel, but it is one which cannot be overlooked where the fuel has to be transported and handled several times, as in railroad work. For railroad work, the best machine in use is a good serviceable engine of sufficient weight, run at a piston speed preferably of 500 f. p. m., and not to exceed 600 f. p. m. with electric ignition, and the hit-or-miss system of governing.

The installation of a gas power plant at a railway station will be accompanied by numerous opportunities for the replacement of hand labor by power. Thus turntables are readily operated by electric motors, while coal handling, rock crushing and the like are conveniently done. The operation of swing or drawbridges may be greatly facilitated by an available source of power, and numerous local applications will suggest themselves.

The success of internal-combustion motors for propelling automobile vehicles has suggested their application to motor and inspection cars, and such machines are coming into general use.

"Such cars really consist of a gasoline automobile running on railroad rails. They are much speedier, and if time has any value, are much more economical than human labor in propelling the car, tools and men. They are usually fitted with air-cooled motors, so that the water-jacketing of the cylinder, with its attending troubles and inconveniences and the necessity for transporting a tank of water are all eliminated. These cars seem to be giving the best satisfaction and it is stated that 'one of them recently completed a bridge inspection trip of 1,500 miles, carrying four men and inspection tools, and made the trip on 45½ gal. of gasoline, making frequent stops to inspect bridges and culverts along the line, and attaining a speed of 25 miles an hour.' This is a fuel consumption of three gallons of gasoline per 100 miles."

In addition to any special applications, there is every reason to believe that the gas engine is well adapted for use in connection with central power stations and railroad shops. Here the fuel economy plays an important part, since modern gas engines fairly rival the steam engine in running qualities, while a gas engine of medium size is as economical of fuel as the largest and most completely equipped triple expansion steam engine.

"Some of the advantages of the gas engine for central stations are: Minimum fuel consumption; low cost of operation and maintenance; simplicity of equipment; only two auxiliaries required, namely, an air compressor for starting the engine and a magneto, or dynamo, for producing current for electric ignition; quick starting; no 'standby' losses; the light load efficiency is superior to that of the steam engine; the

waste heat of the jacket water and of the exhaust gases can be used for heating buildings; no danger from explosion; energy can be stored during light loads in one or more gas holders at less cost than by any other means; the greatest efficiency does not demand the use of the largest possible units, and hence the subdivision of the power among a number of smalled units gives better economy. For railroad work it is possible to erect either coal-gas or water-gas producers and to use the product in gas engines for the generating electricity, either at central stations or at different points around the shops and yards. The water gas could be carburetted for illuminating purposes, if desirable. The railroads might be able, in the light of recent experiments and experiences, to convince the managers of city gas-light works that it was to their interest to increase the amount of coal gasified in their present works so as to furnish more gas for use in gas engines by the railroad company and at a rate which would make the net cost of power when so generated much less than with steam power."

RAILWAY CONSTRUCTION IN SWITZERLAND.

THE COMPLETION OF THE NEW RAILWAYS IN THE RHAETICON AND ENGADINE DISTRICTS OF SWITZERLAND.

Bulletin Technique de la Suisse Romande.

DURING the past few years there has been completed in that charming portion of Switzerland known as the Engadine some very interesting pieces of narrow-gauge railway construction, involving engineering feats of direct and helical tunneling, bridge construction, and location of a high order. A very complete account of this work is given in an article by M. F. Rey, in a recent issue of the *Bulletin Technique de la Suisse Romande*, with topographical maps, profiles, and tunnel sections, as well as handsome photographs of some of the more picturesque portions.

The Rhaeticon railway system includes several roads of 1 metre gauge, none of these being long, but all of them possessing features of interest for the engineer. The Landquart-Davos line, of 50 kilometres in length, is the oldest of these, followed by the Landquart-Thusis line, 41.18 kilometres long, the Reichenau-Ilanz line, 19.4 kilometres long, and the Thusis-St. Moritz line, 61.7 kilometres in length.

The latest and most important of these lines is the one connecting Thusis with St. Moritz, popularly known as the Albula railway from the fact that it traverses the Albula Pass by an important tunnel, and also called the Engadine railway because of the convenient access which it gives to that district from Coire and from the entire northern portion of Switzerland.

The line starts from Thusis at an elevation of 700.5 metres above sea level, and attains its highest elevation in the middle of the Albula tunnel at 1823.4 metres, a difference of level of 1123 metres. The earlier portion of the road follows up the valley of the Rhine, diverting from thence to the course of the Albula, which it follows, with frequent crossings, viaducts and tunnels until the crest is reached. In many respects this line resembles on a small scale the St. Gothard railway, making the ascent in several instances by means of helical tunnels in the heart of the mountain, owing to the impracticability of effecting the necessary ascent in the open grade of the valley. The summit being attained in a straight tunnel, the descent beyond is effected by similar spiral tunnels and loops, the whole involving numerous difficult and trying problems. The grades range from 2.5 per cent. to 3.5 per cent., these permitting the use of ordinary traction without requiring the employment of rack transmission, the difficulties of the road appearing more in the location and construction than in the operation. Thus, in the section of 12 kilometers in length, between Thusis and Tiefencastel, there are 27 bridges and viaducts, and 13 tunnels, these latter representing 33 per cent. of the section.

Among the most important of the bridges may be mentioned the Solis viaduct, with its masonry arch of 42 metres span, crossing the Albula, which flows 90 metres beneath; and the Landwasser viaduct, composed of six arches of 20 metres span each, constructed

on a 2 per cent. grade and a curve of 100 metres radius, the height from the foot of the piers to the track being 65 metres. There are a number of other viaducts which resemble this latter structure, and all the bridges are constructed with masonry arches with the exception of the central span of the bridge across the Rhine at Thusis, and four small bridges in the Engadine, these being made with metallic girders.

Of the tunnels the most notable is the Albula tunnel, this being the straight piercing at the summit, and being 5,864 metres, or about 3½ miles in length, the longest tunnel which has thus far been constructed for a narrow gauge railway line. The treacherous nature of the rock, and the constant infiltration of very cold water rendered this boring very difficult, and for four-fifths of its length it is lined with masonry. Small niches are provided in the walls of the tunnel as refuges for the inspectors, each post being equipped with telephonic communication to the entrance stations.

Fully as interesting from the viewpoint of the engineer are the helical tunnels, which are included in the approaches to the main Albula tunnel. Thus between Munot and Naz there are three tunnels each forming almost a complete helix in the solid rock, the radius of curvature in each case being 120 metres, and two of the tunnels being superposed one upon the other in the heart of the mountain. In this way a rise of 167 metres is effected in a distance of 5,000 metres, measured along the tortuous line of the railway, or in about 2,000 metres direct distance. Not including the Albula tunnel, the road contains 38 tunnels, with a total length of 10,161 metres, of which 7,742 metres represent masonry lining. Including the Albula tunnel there are 16 kilometres of tunnels on the line, or a little more than one-fourth of the length of the whole railway.

From Thusis to St. Moritz 57 per cent. of the line is straight and 43 per cent. consists of curves. The connection between the straight and curved portions is made by the use of parabolic sections, while the horizontal portions of the line are connected to the grades by curves of 2,000 metres radius in a vertical plane, except at the approaches to stations, where the curvature is reduced to a radius of 1,000 metres.

This road opens up one of the most picturesque portions of Switzerland to convenient travel; a matter of especial importance in view of the extent to which the region has already been visited by those who are seeking restoration to health. The popularity of Davos Platz as a health resort is well known, while St. Moritz is also largely frequented, and the completion of the new railway will add greatly to the number of visitors.

From an engineering point of view the railway will doubtless attract much attention, and the greater altitude of the Albula tunnel over the St. Gothard (the latter being but 1,149 metres above sea level) should be taken into account in considering the structural difficulties which have been so succesfully overcome in its completion.

PATENT LAW ADMINISTRATION.

THE RELATION OF PATENTS AND PATENT LAWS TO THE DEVELOPMENT OF THE MECHANIC ARTS.

Technical Society of the Pacific Coast.

IT has long been the tendency to laud patent protection as one of the great causes of the development of mechanical improvement, and in the United States especially the Patent Office has been held up by many as a sort of beneficial institution from which a stream of wealth has spread over the entire land. That such a view is no longer generally held, at least among scientific engineers, is well known, and the present status of the question is well brought out in two papers presented before the Technical Society of the Pacific Coast by such well known engineers as Mr. George W. Dickie and Mr. John Richards, and published in the Journal of the Association of Engineering Societies.

After reviewing the history of the origin of patents for inventions, and showing them to be the one relic which survived the abolition of the mass of burdensome monopolies in various departments of trade dur-

ing the reign of James I. of England, Mr. Dickie proceeds to consider existing patent practice. He shows that patents seem to be granted upon:

"New contrivances which produce new results;

"New contrivances which produce old results;

"New combinations of old and well-known parts, whether the combination relates to the operation or the result.

"New methods of applying a well-known device.

"The whole reason for the existence of patents is the monopolizing by the inventor, for a limited period, of the benefits derived from an invention, on the supposition that there will result a lasting benefit to the public after the term of the patent has expired.

"A very small percentage of the patents granted meet this condition, for, to do so, they must cover real inventions. The mechanical arts have reached such a stage of development that new combinations of mechanical devices, in the sense of invention, is hardly possible, and, in my opinion, a patent should be issued only where some new contrivance has been invented to produce a new result. I would not have any real inventor go unrewarded, but, in order to recompense the few inventors who have done work worthy of recognition by their fellow-men, it should not be necessary for the public generally, and the mechanical arts in particular, to carry the huge load of patent-protected devices of all sorts described in patent specifications, which, owing to cleverly worded claims, prevent a free application of the proper device to accomplish the end in view."

As an example of the kind of patent which stands in the way of progress, Mr. Dickie cites a broad claim of the combination of a bulkhead, sliding door, and electric motor, this being used to enable the water-tight compartments of a vessel to be separated from each other by the control of the closing of the doors from some central point. He described the fact that such a combination was specified by the United States Navy Department, and that he himself had made such a combination, and discussed it with the officer who subsequently obtained the patent. Such a patent, in Mr. Dickie's opinion, is lacking in invention, such combinations being constantly made by engineers and draftsmen in the course of their daily work as part of the practice of their profession.

Mr. Dickie states his position as follows:

"I do not wish to be understood as opposed to all patents. I believe in rewarding everyone who, by invention or skill, succeeds in making new combinations of well-known devices to accomplish results whereby the public will be ultimately benefited, and I would have such rewards liberal and sure; but patent claims cleverly worded to cover combinations of well-known devices —to accomplish well-known results obtained for business purposes—that are to prevent others from using the same combinations or mechanical equivalents I would abolish, and thereby stop 90 per cent. of the patent business, with decided advantage to the real inventor, who at present is lost amid the multitude of imitation inventors and patent sharps."

In discussing Mr. Dickie's views, Mr. John Richards concedes much of the abuse charged against the present system, but hardly believes that the desired improvement is easy of attainment. He believes that much of the trouble lies in the fact that there are large numbers of able, skilled lawyers and patent solicitors, actively engaged in pushing the interests of the clients, while opposed to them are a limited number of Patent Office examiners, of limited attainments and with but moderate salaries, and without any especial interest in seeing that the work is judicially done. As he well says, the conduct of the United States Patent Office "is an amazing example of routine work, done by rule and apparently without personal discretion—by rules that have grown out of the conduct of the office and the circumstances of procedure."

As examples of the ignorance of patent examiners, Mr. Richards cites the well-known case of the rejection in 1853 of the invention, by Jearum Atkins, of the impulse turbine, an invention which was afterwards taken up abroad, and came back to the United States from Switzerland, Mr. Atkins receiving tardy recognition from the Patent Office in 1875 too late to do him or his country any good. Another example was the manner in which an ignition de-

vice for gas engines was rejected on irrelevant references without being considered on its merits as an invention. Mr. Richards is undoubtedly right that it is not practicable to secure as examiners capable and competent engineers and scientists for the salaries paid by the government when so much better returns can be had by competent men elsewhere. That the ideas and inventions of some of the first engineers of the age should be passed upon by men whom the applicants would not be willing to employ in minor capacities, hardly seems a satisfactory or even intelligent proceeding.

Mr. Richards concludes with the following very significant warning:

"I will venture the opinion that we are at the beginning, or a little beyond the beginning, of a war upon property in inventions, a war which will no doubt be conducted with extreme subtlety by those who own large amounts of capital and who recognize that as the only interest that should absorb the earnings of industrial production.

"As signs in this direction may be mentioned the erratic administration mentioned in this and in Mr. Dickie's paper; the want of room for the Patent Bureau and especially the paucity of legislation and attention given to this subject; the character of the bills now before Congress, and the growing opinion, if not belief, among large owners, that small or individual enterprises such as are founded on patents should not exist.

"The first movement in this war against invention will be to render patent grants unpopular, and finally obnoxious, by representing them as monopolies and by encouraging bad administration.

"The honest administration of the Bureau and of the appellate and circuit courts is seldom called in question, although dealing with vast and intricate interests, and this circumstance has, no doubt, warded off attacks that would otherwise have been made upon the system.

"This claim of honesty and pure administration, however great the errors made, is one of especial weight when so much of an opposite nature characterizes our time, and we may be excused for some congratulation over the fact that engineers and mechanics deal with truth and ascertain facts, and that even the romancers never choose their villainous characters from these callings."

TECHNICAL EDUCATION IN GERMANY.

A COMPARISON BETWEEN BRITISH AND GERMAN METHODS OF CONDUCTING ENGINEERING EDUCATION.

North-East Coast Institution of Engineers and Shipbuilders.

TECHNICAL education is such a fertile subject for discussion that papers upon the question are of frequent appearance. Many of these are merely repetitions of what has been said before, but practical information is always welcome. Among articles of this latter class must be included the paper presented by Mr. Max Wurl before the North-East Coast Institution of Engineers and Shipbuilders, upon the subject of technical education in Germany. The opinion has prevailed in many parts of the United Kingdom that the methods used in Germany possess advantages over those in vogue in Great Britain, so that a clear presentation of the former by one who is personally familiar with all the details, it of present importance and interest.

Mr. Wurl describes in general the Prussian system of education, this being representative of the other parts of the empire, and emphasises from the start the fact that the kind of technical education which can be conferred on a man depends mainly upon his general education, the latter being the root and organ by means of which the technical training is able to grow.

The German schools are, to a certain extent, under the control of the government, the Minister of Education directly controlling the universities, the secondary and the primary schools being under the direct supervision of local boards. Passing by the primary schools, Mr. Wurl discusses at some length the rivalry between the three types of secondary schools: the *Gymnasium*, the *Realgymnasium* and the *Oberrealschule*. The Gymnasium was the successor to the old mediæval school of the monks,

and clung fast to the old classical training, secure in the privileges acquired with age. The Realgymnasium was on outgrowth of the older school, while the Oberrealschule is distinctly modern, replacing the classics by modern languages, and laying the foundations for subsequent technical training. Until recently, however, the old privileges of the gymnasium were all powerful, and the certificates of the newer institutions were not recognized by the universities. The influence of the present German Emperor, however, has placed all three classes of schools on the same level, and the certificates of any of them grants admittance to all faculties at any German university or technical college. Following the secondary schools, so far as technical education is concerned, come the *Hochschulen* or technical high schools, which have really grown up in Germany during the past thirty years, although some of them being based on older academical foundations, claim a greater age, the Charlottenburg School having recently celebrated, upon this basis, its hundredth anniversary.

"The aims of the technical high schools are to train the student to independent thought in technical affairs. He is taught to take a wide view in all of his considerations and all his doings; to avoid the mistake of one-sidedness which is but too common. All points practical, theoretical, commercial, etc., must be studied with equal care and thoroughness; a failure in any undertaking always shows that something has been overlooked or neglected, and on the other hand we may be sure of success if we include in our considerations all the different conditions according to their importance."

"Every student who wants to take degrees must have had at least one year's workshop practice before his first academical examination. This new clause was not introduced until an enquiry had been made as to the readiness of industrial establishments to accept volunteers in their works. 520 engine-works, shipyards, electrical works, ironworks, foundries, bridge-building firms, etc., have now agreed, and about 1,750 places are available every year, in addition to those provided by the State for training its railway engineers. For this latter group the regulation is that the State Railway engineer students work six months in the fitting shop and two months each in the machine shops, foundry, and pattern shops; they have to keep an account of their work, and being volunteers, receive, of course, no remuneration."

In entering the *Hochschule* the first year is passed by all the students in the study of general sciences, after which an election of some one of the various departments of engineering is permitted. The instruction is by lectures, practical work in drawing and designing, and experimental work in the laboratory. The students enjoy almost perfect freedom, using their time as they choose, it being found that those who have gone far enough to enter upon such a course of study realize the importance of their work and the value of time, and appreciate fully the opportunities which are placed before them. In this respect there is a marked difference between German and British methods, and although it has been doubted that the German plan would work well in England, it does seem as if men who are to make responsible engineers and practitioners should be placed in a position to realize their responsibility. The whole system, lectures, drawing room, laboratory, is such as to bring the student into close personal contact with the professor, tending to an individual development of each student, and the object is manifestly to educate him to self dependence and reliance.

A most important feature in connection with technical education in Germany is the fact that the academically trained engineer generally finds a situation after leaving college. Engineers with Hochschule education are in fairly good demand, especially those who have taken degrees. In this respect the matter is somewhat similar to that in the United States, where the graduates of the engineering schools are in demand, in marked contrast to the state of affairs in Great Britain. Indeed in this respect the British employers are in need of training themselves to the end that they may appreciate the importance of having in their establishments a number of active young men, fully trained in the latest scientific methods. German methods of teaching may not be wholly applicable to use in England, but no system can be made fully effective unless it is appreciated and supplemented by the employers.

THE NATURE OF INVENTION.

A REVIEW OF THE RELATION BETWEEN MECHANICAL DESIGN AND ORIGINALITY IN INVENTION.

J. Fletcher Moulton, K. C.—Junior Institution of Engineers.

WE have reviewed elsewhere in this issue the opinions of certain eminent engineers concerning the question of patent rights in inventions, and we have as a sort of companion subject the important aud valuable address of Mr. J. Fletcher Moulton, K. C., before the Junior Institution of Engineers, upon the question of invention, as viewed by the lawyer.

Mr. Moulton first examines what he calls the "heritage of knowledge" available for present inventors, this consisting of the accumulated growth of mechanical science which narrows as well as widens the field. Doubtless all the fundamental elements of mechanism were originally inventions of importance, and some very interesting pages of history have been written upon this branch of the subject, although the origin of many are lost in the past. Each existing element of mechanism, however, represents a present and future power conferred on mankind. All these existing elements form an important portion of the equipment of the inventor.

The present task of the inventor is too vast to be discussed at any one time, and hence Mr. Moulton limits himself to an examination of those inventions whose object is to produce by mechanical means articles which must otherwise be produced by hand work.

Some have thought that the best solution of such problems would be found in a close imitation of the manual process, but this is not necessarily the case. As Mr. Moulton well says, mechanical movements cannot be expected to replace exactly the functions of two hands whose movements are closely watched by eyes which report to a guiding intelligence, and other methods may often be found more available. Here he brings in a striking analogy.

"Doubtless you have often had to send a message by telegraph to some distant country to which the rate charged per word is high. You write your message as tersely as may be, but even thus its length is formidable. What do you do? You fly to your telegraphic code. It tells you that if you will change the phraseology of your message you can by a single code word represent a whole phrase. You thereupon set to work to recast your message so as to make it capable of being expressed in code words. When you have done so, you have not improved it as a message. It is less terse and less naturally expressed. If you were writing and not telegraphing, you would prefer to use it in its original form. But as now expressed each of the phrases of which it is composed can be sent over the wires in the form and at the price of a single word, and the cost of the whole is but a fraction of what would have been the cost of the message as originally framed. It has been recast in a form suitable for cheap telegraphing. Just so the inventor. He has to find a series of operations which, in their totality, are equivalent to the series of the hand worker. But each of these operations in itself need not be such as would be in hand labour be suitable or even practicable."

As examples of the manner in which hand operations have been "coded" into mechanical form Mr. Moulton cites the development of the sewing machine, which, with its eye-pointed needle, and double thread or chain stitch is quite different from the manual methods of sewing; and numerous similar examples will undoubtedly occur to the reader.

Mr. Moulton discusses the too common tendency of inventors to change and modify their inventions where a steadfast effort along a definite work might lead to success. The example of Babbage, who by continual changing of his plans and ideas left little which was of subsequent use or value, is an instance of the inventor who begins one thing before he has completed another.

From a commercial standpoint, the subject of invention demands especial attention. An invention must be regarded as only the beginning of a commercial enterprise, and when the invention is completed the actual business portion of the task is but begun.

Thus, for example, the linotype, which has to a great extent revolutionized the composition of printed matter, is the result of long and patient work, not only on the part of the inventor, but on the part also of those who were associated with him in making the machine a commercial success. Thousands were expended in experimental work, and it was only after years of work on the part of both inventor and capitalist that the completed machine was ready.

There is little doubt that the invention of the future will be that of the systematic pursuit of a desired end by the united efforts of inventor and promoter, and with the development of scientific methods the old-time chance inventor will be superceded by the scientific investigator, backed by ample means and full technical resources, removing his work from the domain of guess-work and placing it in the field of scientific research.

MACHINE TOOLS AND HIGH-SPEED STEEL.

THE INFLUENCE OF THE INTRODUCTION OF HIGH-SPEED TOOL STEELS UPON EXISTING MACHINE TOOLS.

J. A. Carney—Western Railway Club.

IT is now generally realized that the new high-speed steels have come to stay, and that their general introduction means the supercession of many existing machine tools by those of much greater weight, power, and rigidity. The acceptance of this fact brings up for consideration another problem, the answer to the question, "What is to be done with the old tools?" This matter is discussed in a paper presented before the Western Railway Club by Mr. J. A. Carney, and its timeliness renders it appropriate for review at this time.

Specifications which are being issued for lathes and planers now require that the lathes shall stand ½-inch cut, with ⅛-inch feed at 30 feet per minute, while planers are required to cut ⅝-inch with ½-inch feed at 50 feet per minute in mild steel. Such tools are only beginning to be made, and they must necessarily cost more than their predecessors, but the machine tool builders are preparing to fill such orders, realizing that these are the standard requirements of the immediate future.

"The question arises, What shall be done with a lot of serviceable machines which are not exactly out of date, but which cannot keep up with the high speed steel pace? In a great many cases they can be speeded up and with moderate cuts the output of the tool largely increased, but it is found that the belting commences to give out and cast iron gears break. It is possible to replace cast iron gears with steel, but it is very probable that some other part will be unable to stand the strain, and the machine will be wrecked.

"The effect of belting with increased speed and cut on old tools is most disastrous, and if a tool is worked to its capacity the cost of repairs to belts and purchase of new ones will increase as much as 100 per cent. The belts, if single ply, can be replaced with light double ply at a slightly increased cost and an increased service greater in proportion, and in some cases it may be found economical to equip the machines with new cones, taking a wider belt.

"The possible time saving of high-speed steel, used with old and weak machines, is due to the fact that it will do much heavier work without regrinding and will finish most jobs without having to stop the machine and grind the tools. This item is a most valuable one and will do nearly as much to help a good output as the increased speed and cut."

Mr. Carney puts the question in the form of two queries: "Is it profitable to continue the use of tools for general use not capable of maximum output as calculated to-day? And is it profitable to reconstruct such tools to give greater speed where the design does not allow of much increased strength?"

"In reply to the first: Where the output of a tool is in such demand that it is worked to its limit of capacity, and to increase the output of the shop would mean the purchase of a similar tool, it will pay to get rid of the original tool and buy a machine of up-to-date design, capable of maximum

effort as counted to-day. The single tool of modern design will more than make up its cost in the extra work done. Where a tool is not kept busy all the time it may not be advisable to spend money where increased capacity would mean increased idleness; but even then there would be an argument of cheaper work on account of the faster output.

"In reply to the second question: Increased speed can be obtained in most cases by increasing the speed of the countershaft, but great care must be taken not to tax the old tool beyond its endurance, or a series of annoying and sometimes expensive breakdowns will result.

"It is impossible to give any rule for scrapping or rebuilding old tools, because the conditions of each shop are so different, and a tool that is very nearly worthless in one shop may be a valuable adjunct to some other shop; but as a general proposition it is advisable to purchase a new tool if it can be shown that 20 per cent. of its cost can be saved per year over and above the output of the old tool."

Apart from the modifications which the new steels are making in the tools themselves, there is to be considered the effect which their use is to have upon the men.

As Mr. Carney puts it: "The education of the old-time slow-speed tempered-tool machinist is no small item." High-speed steels and high-speed machine tools necessarily involve high-speed machinists. Instead of scrapping the old men with the old tools, various methods may be employed to reconstruct them. One plan is to rearrange the tools so that the old slow speeds can no longer be obtained at all, and the necessity of putting on new cones for wider belts also permits the necessary alterations to cut out the slower steps. A better plan is to change the temper of the man as well as of the tool and by the introduction of a suitable premium or bonus system of payment cause him to have as great an interest in the increased output as has his employer. In this respect the reconstruction of the whole shop administration may well be carried along together. Modern tools mean higher speeds and lower shop costs. Improved systems of payment again act to reduce shop charges and total costs. Both include some modern method system of shop accounting and cost keeping, so that a complete reorganization of both productive and administrative methods must be carried out if the full benefits of the new processes are to be obtained.

MODERN ICE BREAKERS.

THE DESIGN AND OPERATION OF VESSELS FOR MAINTAINING NAVIGABLE CHANNELS IN ICE-BOUND WATERS.

Arthur Gulston—Society of Arts.

THE necessity for maintaining open channels in waters formerly allowed to be closed during a portion of the year has led to the construction of ice breaking vessels especially fitted, by reason of their strength and powering, to cope with the obstruction. In a paper recently presented before the Society of Arts by Mr. Arthur Gulston, and published in the *Journal* of the society, some account is given of the more powerful of the recent ice breakers, with numerous illustrations.

The first vessels described by Mr. Gulston are those made for use in the Baltic and the North Sea, and these seem very small and weak compared with the powerful vessels since constructed. Thus the *Pilot* built for use in the harbour of Cronstadt was only about 65 feet long, with an engine of 85 horse power, and the *Zarja* and the *Luna*, used in the same waters, were little more than powerful tug boats, capable of keeping a channel open only by constant action. Similar boats have been used at Hamburg for maintaining navigation in winter between Hamburg and Cuxhaven, and the shallowness of the water prevents boats of greater draught being used. The large modern ice breakers depend for their efficiency upon their ability to ride up upon the ice and break down the edge of the sheet by sheer weight, thus "biting" their way through the sheet. Such action requires that the hull shall be constructed with the greatest possible stiffness, the vessel being subjected to stresses which would break an ordinary

ship in two. With this great strength there must be ample power, the combination of the two being needed to oppose the heavy resistances. Vessels of this kind are now in active service in Copenhagen, Kiel, Riga, Stockholm, Amsterdam and other ports, besides many small boats used as post boats and pilot boats in the Baltic, the German Coast, and the Black Sea. A typical example of the boats used in general service is found in the *Sampo*, operating in the port of Hangö, in Finland. This vessel, which was built on the Tyne, has a propeller at each end, the bow engine having 1,200 horse power and the stern engine 1,350 horse power. She is 202 feet long, and 2,000 tons displacement, with a full draught of 18 feet. This boat breaks through field ice of 12 to 16 inches thick at a speed of eight knots, and she can work through drift ice of 8 to 10 feet thick at a rate of two to three knots, also breaking down larger packs without much trouble.

"Coming now to the design of ice breakers and vessels suitable for working in ice, they should have the bow angles and lines so arranged that when they have mounted the ice, and the ice is giving way under the vessel's weight, they must not jamb when returning o be water borne forward, always remembering that they are advancing and should remount the ice. When the ice is broken down it should pass along below the vessel or under the field ice, otherwise it lies on the water and has a tendency to jamb the vessel sidewise. This results in the ice breaker having to smash a larger proportion of ice than necessary, to give side clearance, thus absorbing more power, coal, and time, and probably resulting in having to back and charge the ice. An ice breaker should also be able to turn out of the channel she has cut, and the form of the bow lines has much effect on this manœuvre.

The designs of ice breakers vary so much that there are no certain data to guide builders; but practice has shown that the full forward form of spoon-shaped bow is not successful in hard and packed ice, as the vessel pushes the ice in front of herself, instead of cutting and dispersing it. It should be borne in mind that ice breakers, when charging in heavy ice, are in collision, so to speak, during the whole time they are at work; this therefore, entails much more strengthening at the bow and sides, as the ice to be dealt with becomes more formidable. The shell plating must be considerably increased in small boats, and still more so as the vessels increase in size; additional stringers, stronger decks, and a liberal addition to the number of bulkheads, transverse and longitudinal, as well as many pillars, become a necessity to prevent recurrence of repairs."

The greatest of modern ice breakers is the *Ermack*, built originally for use in the Baltic, but also occasionally employed elsewhere. This vessel is 335 feet long, 71 feet beam, and 8,000 tons displacement with a draught of 22 feet. She was originally fitted with a bow propeller as well as the twin screws at the stern, this propeller, with its independent engine, being intended to aid in breaking up the ice. The bow propeller was found useful for one year old ice, but became choked and useless in Polar field ice, and hence was removed before the vessel was sent to the Arctic. In solid ice two feet thick, with six to twelve inches of snow on top of it, the *Ermack* can make a speed of nine knots, while she can charge and demolish packs of ice twenty to thirty-five feet in thickness.

Especial interest attaches at the present time to the ice breakers on Lake Baikal, in Siberia, these forming a portion of the system of the Trans-Siberian Railway. The *Baikal*, which is the powerful ice breaker for this service, is 292 feet long, and 4,200 tons displacement, and is fitted with three lines of rails for the locomotives and cars forming the train, there being also a promenade deck for the use of the passengers during the crossing. The field ice on Lake Baikal forms 36 inches thick, and also forms heavy packs, but the ice breakers have been found successful in carrying the regular passenger trains and the mails across throughout the winter.

Mr. Gulston described some of the American ice breaker ferry boats, including the *St. Marie* and the *St. Ignace*, used on the Straits of Mackinaw and the *Transfer* which carries the trains of the Michigan Central Railroad across the Detroit river. The paper contains numerous interesting illustrations and valuable information concerning the successful navigation in ice-bound harbours.

THE ENGINEERING INDEX

"THE KEYSTONE IN THE ARCH OF APPLIED SCIENCE."

The following pages form a DESCRIPTIVE index to the important articles of permanent value published currently in about two hundred of the leading engineering journals of the world—in English, French, German, Dutch, Italian, and Spanish, together with the published transactions of important engineering societies in the principal countries. It will be observed that each index note gives the following essential information about every article.

(1) The full title,
(2) The name of its author,
(3) A descriptive abstract,
(4) Its length in words,
(5) Where published,
(6) When published.

We supply the articles themselves, if desired.

The Index is conveniently classified into the larger divisions of engineering science, to the end that the busy engineer and works manager may quickly turn to what concerns himself and his special branches of work. By this means it is possible within a few minutes' time each month to learn promptly of every important article, published anywhere in the world, upon the subjects claiming one's special interest.

The full text of any article referred to in the Index, together with all illustrations, can usually be supplied by us. See the "Explanatory Note" at the end, where also the full titles of the journals indexed are given.

DIVISIONS OF THE ENGINEERING INDEX.

CIVIL ENGINEERING	1005	MARINE AND NAVAL ENGINEERING	1019
ELECTRICAL ENGINEERING	1010	MECHANICAL ENGINEERING	1020
GAS WORKS ENGINEERING	1017	MINING AND METALLURGY	1027
INDUSTRIAL ECONOMY	1017	RAILWAY ENGINEERING	1032

STREET AND ELECTRIC RAILWAYS 1034

CIVIL ENGINEERING

BRIDGES.

Arch.

The Great Railway Arch over the Adda in the Valtellina, Italy (Die Grosse Gewölbte Eisenbahnbrucke über die Adda im Veltelino in Italien) Rudolf Jaussner. With details of the centering and erection of the masonry arch of 70 metres span. 2000 w. Zeitschr d Oesterr Ing u Arch Ver—Jan. 1, 1904. No. 60427 D.

See also Civil Engineering, Construction.

Bridge Moving.

A Novel Engineering Feat. An illustrated description of method used in lowering a 1000-ton drawbridge a distance of more than ten feet by means of floating sand jacks. 2500 w. Ir Age—Dec. 31, 1903. No. 59998.

Moving a Drawbridge on the Lackawanna. An illustrated description of the removal of a double-decked bridge crossing the Passaic River in New Jersey, which involved many novel features. 400 w. Ry Age—Jan. 1, 1904. No. 59991.

Moving a Drawbridge with Sand Jacks. Fine photographs showing views while moving was in progress, with information concerning the work of lowering the

We supply copies of these articles. See page 1037.

bridge over the Passaic River, at Newark, N. J. 2500 w. R R Gaz—Jan. 1, 1904. No. 60067.

The Use of Scows and Sand Jacks in Moving and Lowering a 1000-ton Drawbridge over the Passaic River, at Newark, N. J. Lincoln Bush. An illustrated article describing this work, especially the use of sand jacks. 4500 w. Eng News—Dec. 31, 1903. No. 60035.

Brooklyn Bridge.

A Proposed Plan for Rebuilding the Brooklyn Bridge. An illustrated article giving plans for reconstruction of the suspension bridge between Brooklyn and New York, suggested by Mr. Gustav Lindenthal. 2000 w. Eng News—Jan. 7, 1904. No. 60138.

Erection.

The Erection of the Kemi-Isohaara Bridge in Finland (Die Aufstellung der Kemi-Isohara Brücke in Finnland) K. Snellman. An illustrated account of the erection and launching of a 125-metre span truss on the line of the Norrlandsbahn in Finland. 4000 w. Zeitschr d Ver Deutscher Ing—Jan. 2, 1904. No 60417 D.

Manhattan Bridge.

The Manhattan Bridge Across the East River. Illustrated description of this bridge at New York, the foundations and piers of which are nearly completed. 1800 w. Sci Am—Jan. 23, 1904. No. 60325.

Point Bridge.

The Point Bridge at Pittsburg, Pa., Which Must Be Rebuilt. Illustrates and describes the design of this historic bridge, which must now be rebuilt. 2000 w. Eng News—Jan. 21, 1904. No. 60316.

Railroad Bridges.

Steel Concrete Abutments and Solid Floors for Railroad Bridges. A. O. Cunningham. Illustrates and describes bridges showing new features of reinforced concrete construction. 1400 w. R R Gaz—Jan. 8, 1904. No. 60192.

Swing Bridge.

Pivot Pier Caisson and Operating Machinery for a Heavy Swing Bridge. Illustrates and describes interesting features of a very heavy combined railway and highway bridge soon to be built over the Missouri River at Kansas City, Mo. 1600 w. Eng News—Jan. 7, 1904. No. 60140.

Williamsburg Bridge.

Details of the Williamsburg Bridge Towers. Photographs illustrating some of the typical features of the steelwork connections of the bridge across the East River at New York, with description. 1100 w. Eng Rec—Jan. 16, 1904. No. 60242.

CANALS, RIVERS AND HARBORS.

Breakwaters.

The Construction of Breakwaters (Sulla Costruzione die Moli) C. Verdinois. A comparison of the breakwaters at Bilboa, Boulogne sur Mer, and Palermo, with especial reference to the improvement works at the latter harbor. 4000 w. 3 plates. Rivista Marittima—Dec., 1903. No. 60456 H.

Canal Lift.

A Canadian Lift Lock. Illustrations with brief description of a canal lift at Petersborough, Ontario. 1000 w. Engr, Lond—Jan. 15, 1904. 60399 A.

Canal Traction.

Internal-Combustion Motors for Canal-Boat Traction. Julius Kuster. Translated from *Zeitschrift des Mitteleuropaischen Motorwagen-Vereins.* Reviews the methods attempted for the mechanical propulsion of canal boats, and describes the Deutzer boat motor. 2000 w. Marine Engng—Jan., 1904. No. 60102 C.

See Electrical Engineering, Power Applications.

Irrigation Engineers.

Prospects of Employment for Young Men as Irrigation Engineers. Sir William Willcocks. On the training needed by irrigation engineers. 1400 w. Engr, Lond—Jan. 15, 1904. No. 60395 A.

Nile.

The Irrigation of the Nile Valley. John Ward. An illustrated account of the present condition of Egypt, the effect of the new dams, and other engineering works. 4400 w. Page's Mag—Jan., 1904. No. 60270 B.

Piers.

The Proposed Extension of the North River Pier Head Line Near 23d St., New York City. Gives condensed reports of Mr. Whinery in favor of the proposed extension and of the Board of Engrs. opposing it, with editorial comment. 6000 w. Eng News—Dec. 31, 1903. No. 60034.

River Improvement.

Argentine Rivers. E. L. Corthell. Explains the hydraulic features of the Rio de la Plata and its tributaries, the products of this region, &c., giving reports of surveys and other information. Ill. 6300 w. Eng News—Jan. 7, 1904. No. 60141.

The Artificial Feeding of the Neste (L'Alimentation Artificielle de la Neste) P. Frick. An illustrated account of the works for the diversion of water from lakes in the Pyrenees for the maintenance of the level in the river and canal of Neste in the upper Pyrenees. 1800 w. Génie Civil—Jan. 2, 1904. No. 60405 D.

We supply copies of these articles. See page 1037.

The Improvement of the Yahara River. James M. Gilman. An illustrated account of proposed improvements in a small stream near Madison, Wis., connecting two lakes. 3500 w. Wisconsin Engr—Dec., 1903. No. 59965 C.

Stamboul.

The New Harbor Works at Haidar-Pasha, opposite Stamboul (Die Neuen Hafenwerke von Haidar-Pascha gegenüber Stambul). With illustrations showing the arrangement of the harbor and the construction of the breakwater at Haidar-Pasha, opposite Constantinople. 2000 w. Zeitschr d Ver Deutscher Ing—Jan. 9, 1904. No. 60421 D.

Waterways.

Harbors and Waterways in 1903. A review of the last year's progress, especially in England. 3800 w. Engr, Lond —Jan. 1, 1904. No. 60128 A.

CONSTRUCTION.

Air Lock.

An Air Valve for Regulating the Time of Passing Through an Air Lock: Used in the Kiel Dry-Dock Construction. Illustrated description of an apparatus to make it impossible for workmen to pass through the air lock in so short a time as to cause risk of injury. Also editorial. 1700 w. Eng News—Jan. 21, 1904. 60321.

Building Construction.

Structural Details of the Kuhn-Loeb Building, New York. Details of a twenty-story steel cage structure are illustrated and described. 2200 w. Eng Rec—Jan. 2, 1904. No. 60063.

Building Details.

Supporting an Old Wall from a New Building. Illustrates and describes a difficult piece of work successfully accomplished, in the course of enlarging the Imperial Hotel of New York City. 900 w. Eng Rec—Jan. 16, 1904. No. 60243.

Concrete Construction.

The Use of Concrete Blocks in Manhole Construction. Hugh C. Baker, Jr. Illustrates and describes a type of manhole construction used for subways for electrical cables. 1500 w. Eng News—Jan. 21, 1904. No. 60319.

See Civil Engineering, Bridges.

Dam.

The Avignonnet Dam (Die Talsperre von Avignonnet). C. Andrae. A description of the dam across the river Drac in the Avignonnet valley, Isère, France, in connection with the development of hydraulic power. The entire structure is of concrete. Two articles, 3000 w. Schweiz Bauzeitung—Dec. 19, 26, 1903. No. 60457 each B.

Excavation.

Cost of Earth Excavation by Steam Shovel. Daniel J. Hauer. Gives an account of a month's work done in North Carolina, with remarks on factors affecting cost. 3500 w. Eng News—Dec. 31, 1903. No. 60027.

Factory Architecture.

The Warehouse and the Factory in Architecture. Russell Sturgis. An illustrated critical discussion of buildings of this class. 4300 w. Arch Rec—Jan., 1904. Serial. 1st part. No. 59954 C.

Fireproofing.

Fire Proof Construction in America (Feuersichere Eisenbauten in den Vereinigten Staaten von Amerika) M. Gary. A fully illustrated description of the method of steel skeleton building construction, with casing of fire brick. 4000 w. Zeitschr d Ver Deutscher Ing—Jan. 9, 1904. No. 60420 D.

Foundations.

Foundations. Abstract of a paper read by Baron Siccama at a recent meeting of the Civ. & Mech. Engrs. Soc. Considers raft and sand foundations, the use of piles, the well method, &c. 2300 w. Gas Wld—Jan. 16, 1904. No. 60386 A.

Grade Elevation.

Raising the Grade of Galveston. An interesting illustrated description of the work of building a sea-wall, and raising the grade of the flooded portion of the city above high water, after the almost total destruction in Sept., 1900. 2000 w. R R Gaz—Jan. 1, 1904. 60068.

Rapid Building.

How to Get Despatch in Construction. Discusses facts brought out in a recent paper by Charles Heathcote, bearing upon methods of securing economy and despatch in construction. Considers the building of the Westinghouse Works at Manchester, Eng. 2400 w. Jour Gas Lgt —Dec. 22, 1903. No. 59978 A.

Reinforced Concrete.

A Concrete Arch Bridge with Bar and Stirrups Reinforcement. An illustrated description of the bridge which carries Seeley St. over Prospect Ave., in Brooklyn, New York. It is a skew structure in which small bars and metal netting are used for reinforcing the concrete arch. 1200 w. Eng News—Dec. 31, 1903. No. 60032.

A Concrete-Steel Factory Building with Fifty-two-Foot Roof Girders. Illustrated description of a building in Long Island City, built entirely of reinforced concrete. 3300 w. Eng Rec—Jan. 16, 1904. No. 60240.

A Reinforced Concrete Tunnel (Tunnel in Eisenbetonkonstruktion). L. Zöllner.

We supply copies of these articles. See page 1037.

Illustrating a tunnel lining on the Wayss system near Wasserburg, Bavaria. 1000 w. Beton u Eisen—No. V. 1903. No. 60480 H.

Big Rock Creek Concrete-Steel Arch on the Chicago, Burlington & Quincy Railway. Illustrates and describes a bridge being built near Plano, Ill., to replace a steel bridge. 1000 w. Eng Rec—Jan. 2, 1904. No. 60062.

Bridge Construction in Munich (Münchener Brückenbauten). W. Binswanger. Describing especially the new Cornelius bridge across the Isar. 4000 w. Beton & Eisen—No. V. 1903. No. 60481 H.

Reinforced Concrete Arch Bridge Over the Yellowstone River, Yellowstone National Park. H. M. Chittenden. Illustrated description of the bridge and its erection. 2300 w. Eng News—Jan. 14, 1904. No. 60248.

Some of the Causes of Recent Failures of Reinforced Concrete. Julius Kahn. The writer's views as to the causes of failure of a material in which he has the utmost confidence. 4200 w. Eng News—Jan. 21, 1904. No. 60322.

The Calculation of the Stresses and the Practical Design of Structures of Steel Concrete. Walter W. Colpitts. Considers the properties which render it adaptable to railway structures, discussing its applications and describing designs and calculations. Ill. 6600 w. Ry Age—Jan. 8, 1904. No. 60167.

The Extension and Elasticity of Reinforced Concrete (Allongement et Elasticité du Beton dan les Pièces Armées) G. Considère. A discussion of the results of experiments made in the laboratory of the Ponts et Chaussées with especial reference to the elasticity of the concrete itself. A parallel translation in German is given. 3000 w. Beton u Eisen—No. V. 1903. No. 60479 H.

The Graphical Computation of Reinforced Concrete Beams (Die Graphiche Berechnung von Balken aus Eisenbeton) F. von Emperger. Discussing the application of grapho-statistics to reinforced concrete structures with a general diagram for practical use for beams. 4000 w. Beton u Eisen—No. V., 1903. No. 60483 H.

Roads.

An example of Thin Macadam Road Construction Along the Charles River, Mass. J. Albert Holmes. Describes the road previous to the placing of the macadam surface and the work. Ill. 800 w. Eng News—Jan. 14, 1904. No. 60251.

Shield.

An Improved Tunneling Shield. Describes a type of shield designed by Cornelius G. Hastings, for application to tunnels of a considerable range of sizes through various classes of material, seeking to overcome the difficulties encountered in submarine and some land tunneling. Ill. 1500 w. Eng Rec—Jan. 2, 1904. No. 60061.

Struts.

Statical Investigations upon Crooked Struts (Statische Untersuchung Einfach Gekrümmter Stäbe) G. Ramisch. A mathematical analysis, deriving formulas for various sections and shapes. 3500 w. Zeitschr d Oesterr Ing u Arch Ver—Jan. 1, 1904. No. 60425 D.

Tunnels.

The Cincinnati Water-Works Tunnel. Paul G. Brown. An illustrated description of the construction. 1500 w. Eng News—Dec. 31, 1903. No. 60036.

The Highest Tunnel in Europe. Brief illustrated description of the Albula tunnel in Switzerland. 600 w. Sci Am Sup—Dec. 26, 1903. No. 59944.

The Pennsylvania Tunnel at New York City. Gives a diagram showing the location of these tunnels under the Hudson and East Rivers, with an outline of the work. 1600 w. Ills. Sci Am—Jan. 16, 1904. No. 60246.

The Simplon Tunnel. Reviews the history of this great undertaking, commencing a detailed description of the construction. Ill. 5400 w. Trac & Trans—Jan., 1904. Serial. 1st part. No. 60294 E.

Underpinning.

Underpinning a Corner Column on a Slender Pier. Brief illustrated description of work of special difficulty executed in New York. 600 w. Eng Rec—Jan. 9, 1904. No. 60188.

MATERIALS.

Brick Making.

Brick Making Plant of the Western Brick Co., Danville, Ill. Illustrated description of plant for the manufacture of building and paving brick. 2400 w. Eng News—Jan. 14, 1904. No. 60250.

Buckling.

More Accurate Formulas for Buckling (Genauere Formeln für die Knickkraft) Adolf Francke. With especial reference to pillars and struts of reinforced concrete giving a mathematical analysis. 3000 w. Beton u Eisen—No. V. 1903. No. 60482 H.

Cement.

The Cost of Raw Materials for Portland Cement Manufacture. Morris M. Green. Information of interest, giving estimates. 1800 w. Eng Rec—Jan. 23, 1904. No. 60356.

Cement Works.

The Almendares Portland Cement

We supply copies of these articles. See page 1037.

Works, Cuba. An illustrated description of works near Havana. 2500 w. Eng Rec—Jan. 9, 1904. No. 60184.

Clays.

On the Role Played by Iron in the Burning of Clays. Prof. Edward Orton, Jr. An illustrated article giving the principal facts concerning the behavior of iron in clay burning. 2000 w. Brick—Jan. 1, 1904. No. 60183.

Corrosion.

The Protection of Steel from corrosion. Charles L. Norton. Extract from report of the Insurance Engineering Experiment Station. Describes tests upon metal embedding in concrete. 1600 w. Eng News —Jan. 14, 1904. No. 60249.

Dynamite.

Heating a Dynamite Storage House. Illustrated description of the type of dynamite storehouse adopted by the Fire Commissioners of New York. 700 w. Metal Work—Jan. 9, 1904. No. 60075.

Terra Cotta.

The "New York" Reinforced Terra Cotta Arch. An illustrated account of an official test made of this new type of building construction. 4500 w. Ins Engng—Dec., 1903. No. 59955 C.

MEASUREMENT.

Field Engineering.

Two Problems in Field Engineering. Arnold Emch. Gives the solution of an application of the theory of bicircular quartics, and an application of projective geometry. 1000 w. Eng News—Dec. 31, 1903. No. 60037.

Flow.

Methods of Measuring the Flow of Streams. John C. Hoyt. Explains the method used by the U. S. Geological Survey. 1800 w. Eng News—Jan. 14, 1904. No. 60253.

Tide Predictor.

Lord Kelvin's Automatic Tide Predictor. An illustrated description of this machine which has recently come into the possession of the National Physical Laboratory of Great Britain. 3500 w. Sci Am Sup—Jan. 23, 1904. No. 60328.

Water Gauge.

The Haskell Self-Registering Water Gauge. G. A. M. Liljencrantz. Illustrates and describes the main features of this gauge for recording the level of streams, etc., invented by E. E. Haskell, its operation, reliability, and manner of using. 6000 w. Jour W Soc of Engrs—Dec., 1903. 60341 D.

MUNICIPAL.

Fire Fighting.

Philadelphia's New Fire Fighting Service. An illustrated description of central pumping station and independent pipe system whereby high pressures are obtained directly at the hydrants. 3200 w. Ir Age—Jan. 21, 1904. No. 60308.

Pavements.

The Economic Designing of Pavements. A. W. Dow. Read at Baltimore meeting of the League of Am. Municipalities. Discusses ancient and modern methods, and three methods that the writer thinks desirable. 4200 w. Munic Engng—Jan., 1904. No. 59971 C.

Sanitation.

Sanitary Engineering in 1903. A review of the progress made during the past year in England, discussing present methods. 2500 w. Engr, Lond—Jan. 1, 1904. No. 60130 A.

Sanitary Law. H. Harcourt Verden. Read before the Inst. of San. Engrs., Ltd. Deals only with points of importance to sanitary engineers in Great Britain. 3300 w. Engng—Jan. 1, 1904. No. 60215 A.

Septic Tank.

The Septic Tank for the Treatment of Sewage at the Soldiers' Home Near Santa Monica, Cal. James D. Schuyler. Illustrated description of the tank with statement of its operation. 3000 w. Munic Engng—Jan., 1904. No. 59969 C.

Sewage.

Sewage Disposal in Iowa. Prof. A. Maraton. Information and illustrated descriptions of plants in various parts of the state. Discussions. 12300 w. Jour W Soc of Engrs—Dec., 1903. No. 60340 D.

Theatre Fire.

The Chicago Theatre Fire. Gives a description of the Iroquois Theatre, showing sketch plans and sections, and reviewing the causes of the disaster. 3500 w. Eng News—Jan. 7, 1904. No. 60142.

The Structural Effects of the Iroquois Theatre Fire. An illustrated article showing the condition of the building after the fire, and explaining the arrangement. Also editorial. 2000 w. Eng Rec—Jan. 9, 1904. No. 60187.

Waste.

The Sanitary Disposal of Municipal and Institutional Waste by Cremation. Selections from a paper by W. F. Morse, read at meeting of the Am. Pub. Health Assn., giving a statement of reasons for the success of garbage destruction in England and the practical failure in America. Ill. 1800 w. Munic Engng—Jan., 1904. No. 59970 C.

WATER SUPPLY.

Conduit.

The Conduit of the Jersey City Water

We supply copies of these articles. See page 1037.

Supply Company. Illustrated detailed description of the steel pipes and the terminal gate house and connections. 2500 w. Eng Rec—Jan. 9, 1904. Serial. 1st part. No. 60185.

Filtration.

The Belmont Filtration Works. John W. Hill. Illustrated detailed description of these works for filtering the supply of West Philadelphia. 5500 w. Jour Fr Inst—Jan., 1904. Serial. 1st part. No. 60333 D.

The Failures and the Possibilities of Water Filtration. Allen Hazen. Abstract of remarks made at the Sanitary Con. of the Health Officers of Conn. Discusses the reasons for some failures. 2000 w. Eng News—Dec. 31, 1903. No. 60029.

The Filter Galleries for the Water Works of Laredo, Texas. A. L. McLane. Detailed description. 1300 w. Eng Rec—Jan. 9, 1904. No. 60186.

Impure Water.

Some Lessons of the Butler Typhoid Epidemic. Editorial on the need of sanitary reforms and the deaths due to polluted water. 1700 w. Eng News—Dec. 31, 1903. No. 60033.

Mains.

Relocating a Large Pumping Main Under Pressure, at Philadelphia. Seth M. Van Loan. Outlines the reasons why the undertaking was necessary, and gives an Illustrated description of this work. 11000 w. Eng Rec—Jan. 23, 1904. No. 60355.

Meter Tests.

Some Six-Inch Meter Tests and How They Were Made. Frank C. Kimball. Illustrates and describes apparatus and methods used in testing, stating results. Discussion. 9600 w. Jour N E Water Wks Assn—Dec., 1903. No. 60336 F.

Reservoirs.

Covering the Natick, Mass., Reservoir with a Concrete Roof. Frank L. Fuller. Illustrated description of this work. 11000 w. Jour N E Water Wks Assn—Dec., 1903. No. 60338 F.

The New Sebago Lake Reservoir of the Portland Water Company. Edmund M. Blake. An account of the supply of Portland and the recent improvements to increase it which involved interesting engineering features. Ill. 4000 w. Eng Rec—Jan. 23, 1904. No. 60352.

Storage.

The Storage of Flood Water. Prof. Henry Robinson. From a paper read before the British Assn. of W.-Wks. Engrs. Considers the subject principally as related to England. General discussion. 4500 w. Jour Gas Lgt—Dec. 22, 1904. No. 59980 A.

Stray Currents.

See Electrical Engng., Measurement.

Supply.

New Water Supply for Margate. An illustrated article describing the new water-works for this English seaside resort. 1100 w. Engr, Lond—Dec. 25, 1903. No. 59981 A.

Typhoid.

The Responsibility for Controlling the Spread of Typhoid Fever. Editorial on the causes of epidemic typhoid, and what should be done to prevent communication. 3000 w. Eng News—Jan. 21, 1904. No. 60320.

ELECTRICAL ENGINEERING

COMMUNICATION.

Exchange.

The New Automatic Telephone Exchange at Grand Rapids, Mich. Edward J. Hart. Illustrated description. 2500 w. Elec Wld & Engr—Jan., 1904. No. 60373.

Printing-Telegraph.

The Berlin Printing-Telegraph Central Station. Dr. Alfred Gradenwitz. Illustrated detailed description. 1000 w. Sci Am—Dec. 26, 1903. No. 59942.

Simultaneous.

Simultaneous Telegraphy on the Hughes System and Telephony (Doppelter Hughesbetrieb und Gleichzeitiges Fernsprechen in Doppelleitungen). H. Pfitzner. Illustrated description of a system, modified from that of Dejongh, used in the German Imperial telegraph office. 1000 w. Elektrotech Zeitschr—Dec. 17, 1903. No. 60431 B.

Space Telegraphy.

Blockmann Radio-Telegraph System. A. Frederick Collins. Shows how this system is the outcome of experiments of Heinrich Hertz in refracting electric waves, and briefly describes the invention. Ill. 1800 w. Elec Wld & Engr—Jan. 16, 1904. No. 60261.

Major Wireless Telegraph Progress for the year 1903. Joseph B. Baker. Reviews the work of various experimenters during the year. 3300 w. Elec Rev, N. Y.—Jan. 9, 1904. No. 60182.

The De Forest Wireless Tests Across the Irish Channel. An illustrated account of a series of experiments conducted under

We supply copies of these articles. See page 1037.

the auspices of the British post-office. 900 w. Sci Am—Jan. 16, 1904. No. 60244.

The Variation of Potential Along the Transmitting Antenna in Wireless Telegraphy. C. A. Chant. A detailed account of an examination of the aërial wire used to radiate the waves in wireless telegraphy. 5000 w. Am Jour of Sci—Jan. 1904. No. 60329 D.

Wireless Telegraphy Theory. An explanation of phenomena, showing the propagation at great distances resolves itself into hemispherical waves. Discusses views of Prof. Blondel. 1300 w. Elec Wld & Engr—Jan. 2, 1004. No. 60086.

See Electrical Engineering, Measurement.

Telegraphy.

Present Conditions in Telegraphy. Francis W. Jones. Reviews the improvements to increase the efficiency, giving records of remarkable speeds, and noting proposed inventions. 1200 w. Elec Rev, N. Y—Jan. 9, 1904. No. 60181.

Telephony.

The Cost of the Glasgow Corporation Telephone System. Analyzes the capital account under its natural divisions, extracting the average cost per unit of work, and determines the average capital cost per working line. 2500 w. Engng—Dec. 25, 1903. No. 60117 A.

The Efficiency of Modern Telephone Equipment. M. A. Edson. Abstract of a paper read before the Chicago Elec. Assn. Discusses the present efficiency of the engineering elements which enter into the construction of a modern exchange. 3000 w. Am Electn—Jan., 1904. No. 60108.

The Telephone in 1903. C. J. H. Woodbury. Reviews the improvements during the past year. 1500 w. Elec Rev, N. Y—Jan. 9, 1904. No. 60180.

Time Service.

The Naval Observatory's New Year's Greeting to the World. George C. Maynard. An account of the great telegraphic achievement by which the ending of the year 1903 in Washington was signalled around the world. 1400 w. Elec Rev. N. Y—Jan. 9, 1904. No. 60177.

DISTRIBUTION.

Switches.

An Emergency or Master Switch for Central Stations. W. M. Thornton. Suggests that an auxiliary switch be so fitted that, in emergency, all the fields could be simultaneously short-circuited. 1500 w. Elect'n, Lond—Jan. 15, 1904. No. 60390 A

Switch Construction. N. C. Woodfin. An illustrated description of a recently designed single-knife switch, aiming at simplicity and effectiveness. 1400 w. Elec Rev, Lond—Dec., 25, 1903. No. 59977 A.

Wiring.

Alternating Current Wiring. George T. Hanchett. Gives means of calculating wires for alternating current circuits of small magnitude. 1200 w. Cent Sta—Jan. 19, 1904. No. 60222.

The Grounded Neutral. R. S. Hale. Discusses four ways in which the wiring on a three-wire system with grounded neutral can be done more cheaply and as safely as at present. 1700 w. Elec Wld & Engr—Jan. 16, 1904. No. 60260.

ELECTRO-CHEMISTRY.

Batteries.

Fuel and Heat Batteries. C. J. Reed. A description of the Reid battery. 2000 w. Elec-Chem Ind—Jan., 1904. No. 60174 C.

Bleaching.

Two New Forms of Electrolytic Cell for Production of Bleaching Solutions. John B. C. Kershaw. An illustrated description of two new forms of apparatus for the production of hypochlorite solutions. 1700 w. Elec Rev, Lond—Dec. 25, 1903. No. 59976 A.

Carbon Cell.

Electricity Direct from Carbon. Prof. Richard Lorenz. Abridged translation of a paper read before the Physical Society of Zurich. A study of the various methods, showing that the carbon cell is theoretically possible, and stating the difficulties involved. 4500 w. Elec-Chem Ind—Jan., 1904. No. 60173 C.

Electric Furnaces.

Electric Furnace Industries in 1903. F. A. J. Fitz Gerald. A review of the past year of the industries using electric furnaces, giving examples that indicate probable future developments. 2000 w. Elec-Chem Ind—Jan, 1904. No. 60170 C.

Electrometallurgy.

The Electrical Manufacture of Steel. P. McN. Bennie. An abridged translation of M. Gustave Gin's description of his latest process for the production of steel by electrical means. Ill. 3300 w. Elec-Chem Ind—Jan., 1904. No. 60175 C.

Electro-plating.

Differential or Localized Electro-Plating. Sherard Cowper-Coles. Illustrated description of methods. 1100 w. Elec-Chem & Met—Dec., 1903. No. 60345 E.

Electrotypes.

Rapid Methods for Producing Electrotypes. Sherard Cowper-Coles. Illustrated descriptions. 800 w. Elec-Chem & Met—Dec., 1903. No. 60346 E.

Elements.

The Rare Elements. Victor Lenher.

Considers the new radioactive elements and their actions, and also other elements and their characteristics. 3000 w. Elec-Chem Ind—Jan., 1904. Serial. 1st part. No. 60172 C.

Researches.

Recent Electrical Researches by Berthelot. Translated from the French. The relation between the intensity of the voltaic current and the manifestation of the electrolytic output. 3600 w. Sci Am Sup—Dec. 26, 1903. No. 59945.

Review.

Electrochemistry in 1903 (Die Elektrochemie im Jahre 1903). Dr. M. Krüger. A general review. Serial. 1st part. 4000 w. Elektrochem Zeitschr—Jan., 1904. No. 60451 G.

The Present Status of the Electro-Chemical Industries. Joseph W. Richards. Reviews briefly the various industries showing promising progress in most of them. 2500 w. Elec-Chem Ind—Jan., 1904. No. 60169 C.

Smelting.

The Electric Smelting of Iron and Steel. An illustrated article describing various processes and investigating the electric methods of smelting steel, concluding that under existing conditions the actual manufacture of iron and steel by electric methods can not be profitably carried on. 4500 w. Ir & Coal Trds Rev—Jan. 15, 1904. No. 60518 A.

Storage Batteries.

Care and Management of Storage Batteries. Edward Lyndon. Outlines the troubles to which batteries are subject and the methods of treating them, also indicates the more important records which should be taken. 1800 w. Elec Rev, N. Y—Jan. 23, 1904. Serial. 1st part. No. 60359.

The Edison Battery—Details of Construction. Gives the main constructional details of this new cell. Ill. 2500 w. Auto Jour—Jan. 2, 1904. No. 60199 A.

The Edison Storage Battery. Hugh Dolnar. A report of the Edison iron-nickel battery. 4500 w. Automobile—Dec. 26, 1903. No. 59928.

The Edison Storage Battery. Hugh Dolnar. Information of interest with condensed report of W. Hibbert. 2500 w. Am Mach—Dec. 31, 1903. No. 60003.

See also Mechanical Engineering, Automobiles.

Stripping.

Electrolytic Stripping of Metals. Prof. Charles F. Burgess. An illustrated detailed description of the process used. 4000 w. Elec-Chem Ind—Jan., 1904. No. 60171 C.

ELECTRO-PHYSICS.

Electric Waves.

See Electrical Engng., Measurement.

Electrostriction.

A Critical Review of Electro-striction. Louis T. More. Explains the term, and reviews investigations made, criticizing the claims made. Also editorial. 5000 w. Elec Wld & Engr—Jan. 16, 1904. No. 60258

Insulation.

A Method for Measuring the Insulation of Liquids (Eine Methode zur Bestimmung der Isolierfähigkeit von Flüssigkeiten). Paul Humann. Illustrated description and results of measurements of electrical resistance of oils, etc., at different temperatures. 5000 w. Elektrotech Zeitschr—Dec. 31, 1903. No. 60436 B.

Bitumen in Insulating Compositions. D. A. Sutherland. A digest of known data, and a contribution to the study of bitumen, its sources, properties and uses for electrical purposes. 8000 w. Elec-Chem & Met—Dec., 1903. Serial. 1st part. No. 60344 E.

The Electrical Properties of Porcelain Insulators at High Voltages (Die Elektrischen Grössen von Porzellanisolatoren bei Hoher Spannung). Rob. M. Friese. Experiments determining the resistance, leakage currents, capacity, etc., of different styles of insulators, with diagrams, illustrations and tables. 1500 w. Elektrotech Zeitschr—Dec. 17, 1903. No. 60430 B.

Magnet Windings.

The Calculation of Magnet-Windings. Cecil P. Poole. An explanation of method used by the writer, giving tables, formulae, etc. 4500 w. Am Elect'n—Jan., 1904. No. 60111.

Protection.

Protection of Electrical Apparatus From Lightning and Other Destructive High Potentials. Howard R. Sargent. Discusses the best protection from such troubles, calling attention to features of importance. 2400 w. Elec Wld & Engr—Jan. 2, 1904. No. 60083.

Puncture.

The Law of Electric Puncture (Das Gesetz der Elektrischen Durchschläge). C. Baur. A simple law for determining the voltages which will puncture different thicknesses of various dielectrics, and records of experiments. 800 w. Elektrotech Zeitschr—Jan. 7, 1904. No. 60441 B.

Radioactivity.

Radioactivity and Radiation. Dr. Louis Bell. Calls attention to the imperfect knowledge as yet of some of the essential factors in the phenomena. 1200 w. Elec Wld & Engr—Jan. 23, 1904. No. 60370.

We supply copies of these articles. See page 1037.

Sir Oliver Lodge on Radium. Abstract of a lecture on "Radium and its Meaning." 2800 w. Elec Engr, Lond—Jan. 8, 1904. No. 60290 A.

Roentgen Apparatus.

The Orthodiagraph, an Apparatus for Determining the True Shape and Size of Internal Organs. Illustrates and describes the apparatus and its operation. 900 w. Sci Am—Jan. 16, 1904. No. 60245.

GENERATING STATIONS.

Canandaigua.

A Modern Electric Railway Power Plant, Canandaigua, N. Y. An illustrated description of a finely equipped plant. 2000 w. Eng Rec—Jan. 16, 1904. No. 60241.

Commutation.

The Commutation of Current in Dynamos (Die Stromwendung in Kommutierenden Maschinen). Karl Pichelmayer. Paper before the Vienna Elektrotechnischer Verein, on sparking at the commutators of direct-current machines and means for preventing it, with diagrams and discussion. 4000 w. Zeitschr f Elektrotechnik—Jan. 3, 1904. No. 60447 D.

The Theory of Commutation (Zur Theorie der Stromwendung). Karl Pichelmayer. Illustrated discussion of sparking at the commutators of direct-current machines and of commutation theories. 800 w. Elektrotech Zeitschr—Dec. 31, 1903. No. 60435 B.

Double-Current.

The Copper Losses and Economy of Double-Current Generators (Kupferverluste und Ausnutzungsfähigkeit der Doppelstromgeneratoren). Felix Horschitz. An Illustrated discussion of the action of the combined direct and alternating currents in the armature, and a comparison with direct current alone. 3000 w. Elektrotech Zeitschr—Jan. 14, 1904. No. 60442. B.

Electrical Power.

The Production of Electrical Power. The first of a series of articles aiming to give a popular explanation of methods employed in generating and utilizing electric current for tramway purposes. Tram & Ry Wld—Jan. 14, 1904. Serial. 1st part, No. 60521 B.

Gas Power.

Central Station Operated by Gas Power. An illustrated detailed description of the plant of the Bradford Electric Light & Power Co., in Pennsylvania. 2300 w. Am Elect'n—Jan., 1904. No. 60105.

Heyland Generator.

A New Alternator With Direct Excitation by Alternating Currents (Eine Neue Wechselstrommaschine mit Direkter Erregung durch Wechselstrom). Alexander Heyland. Illustrated paper before the Elektrotechnischer Verein, with extended discussion. Current from the machine passes through a commutator direct to the field coils. 8000 w. Elektrotech Zeitschr—Dec. 17, 1903. No. 60432 B.

Hydro-Electric.

Hydro-Electric Power System, Near Sassenage, Isere, France. E. Guarini. Illustrated description. 1000 w. Engr, U. S. A—Jan. 15, 1904. No. 60268 C.

The First Hydro-Electric Station of Greece. E. Guarini. An illustrated account of the hydro-electric pumping station for the drainage of Lake Copais. 1800 w. Engineering Magazine—Feb., 1904. No. 60474 B.

Plant of the Columbus Power Company, Columbus, Georgia. Illustrated description of a plant built to furnish electric power for public sale and to drive a mill. 4000 w. Eng Rec—Jan. 16, 1904. No. 60239.

The Chèvres Hydraulic Station Near Geneva. B. F. Hirschauer. An illustrated description of one of the largest and best equipped plants in Europe. 3000 w. Elec Rev, N. Y—Jan. 23, 1904. No. 60360.

Water-Power Electrical Development in Northern Indiana. Illustrated account of the Twin-Branch power-house, ten miles west of Elkhart, Ind., on the St. Joseph river. The first of a number of projected plants. 1400 w. Eng Rec—Jan. 23, 1904. No. 60353.

Water Power Electrical Generating Plant at Riva, Tyrol. Franz Koster. Illustrates and describes a hydro-electric plant serving less than 8000 people. 1500 w. Elec Wld & Engr—Jan. 2, 1904. No. 60084.

See also Mechanical Engng., Hydraulics.

Statistics.

Statistics of the Electric Stations in Germany (Statistik der Elektricitätswerke in Deutschland). Complete statistical tables of all the German central stations on April 1, 1903, with editorial. 12000 w. Elektrotech Zeitschr—Dec. 24, 1903. No. 60433 B.

Storage Batteries.

Operation of Storage Batteries and Boosters. W. T. Fernandez. Considers the daily operation of batteries, and cell-switches and boosters. Diagrams. 2000 w. Am Elect'n—Jan., 1904. No. 60112.

Vienna.

The Vienna, Austria, Municipal Light and Power Plant. Franz Köster. Illustrated detailed description. 3300 w. Elec Rev, N. Y—Jan. 9, 1904. No. 60178.

Weak Currents.

Modern Methods of Generating Weak

Electric Currents (Ueber Moderne Stromquellen fur Schwachstrombetriebe). Emil Muller. Discussing the use of dynamos, storage batteries, etc., for the generation of weak currents for telegraphy and similar service. Two articles, 7500 w. Zeitschr d Oesterr Ing u Arch Ver—Dec. 18, 25, 1903. No. 60424 each D.

See also Mechanical Engineering, Steam Engineering.

LIGHTING.

Distribution.

On the Distribution of Light from Incandescent Lamps. Lancelot W. Wild. On the choice of lamps for various uses, and the measurement of candle-power. 900 w. Elec Rev, Lond—Jan. 1, 1904. No. 60203 A.

Enclosed Arc.

Notes on the Enclosed Electric Arc. Elihu Thomson. Explanation of differences between the enclosed and open arc, particularly considering the enclosed arc and its working. 3000 w. Cent Sta—Jan., 1904. No. 60223.

Incandescent Lamps.

The Gas That Failed. Alton D. Adams. Review of the growth of the incandescent lamp as compared with gas. 2500 w. Elec Wld & Engr—Jan. 2, 1904. No. 60085.

Lamps.

Intensive Electric Lamps (Mitteilungen ueber Intensivflammen bogen lampen). H. Zeidler. A description of recent lamps made by the A. E. G., using carbons impregnated with salts acting to increase the length of the arc. 1000 w. Glasers Annalen—Jan. 15, 1904. No. 60454 D.

MEASUREMENT.

Form Factor.

The Measurement of the Form Factor of an Alternating Voltage. Translation of an article by P. Rose and A. Kuhns in *Elektrotechnische Zeitschrift*. The form factor is the ratio of the effective value to the average value of the voltage. Gives methods of measurement. 1400 w. Elec Engr, Lond—Jan. 8, 1904. No. 60289 A.

Meter.

New Two-Rate Meter. E. S. Shoults. An illustrated description of the Aron double-tariff meter, with statement of the advantages. 1700 w. Elec Rev, Lond—Jan. 1, 1904. No. 60204 A.

Potential Regulator.

Compensated Potential Regulator for Single-Phase Current (Kompensieter Potentialregulator für Einphasenstrom). Dr. L. Fleischmann and Dr. F. Eichberg. Theory and description, with diagrams. 600 w. Zeitschr f Elektrotechnik—Jan. 10, 1904. No. 60448 D.

Potentiometer.

Potentiometer. W. Clark Fisher. An illustrated description of a new instrument, showing its essential difference and improvement on the older form. Ill. 3500 w. Elect'n, Lond—Jan. 15, 1904. No. 60391 A.

Resistances.

The Accurate Measurement of Small Resistances with the Kelvin Double Bridge. W. Jaeger, S. Lindeck, and H. Diesselhorst. From the *Physics-Technical Reichsanstalt*. Describes the measurement of resistances comprising principally standards from 0.1 ohm to 0.0001 ohm. 900 w. Elec Rev, N. Y—Jan. 2, 1904. Serial. 1st part. No. 60010.

Slip Meter.

A New Slip Meter (Ein Neuer Schlüpfungsmesser). Angelo Bianchi. Illustrated description of methods and apparatus for measuring the slip of induction motors. 800 w. Elektrotech Zeitschr—Dec. 24, 1903. No. 60434 B.

Speed Indicators.

Electrical Speed Indicators—Some Unsuccessful Attempts. A. S. Cubitt. Gives an illustrated description of experimental investigations made by the writer, stating the reasons for their proving more or less unsuccessful. 3500 w. Elec Engr, Lond—Jan. 1, 1904. No. 60200 A.

Stray Currents.

Measurements of Electric Currents on Gas and Water Pipes in Geneva, Switzerland. Gives results of a recent electrical survey. 1000 w. Eng News—Dec. 31, 1903. No. 60031.

Testing.

Testing Large Alternators. W. E. Burnand. Describes method which is believed to overcome objections made to other methods. The armature circuit is divided into quarters so as to abolish the unbalanced mechanical stresses forcing alternating current of the same frequency as that of the generator through the armature coils. Also editorial. 3700 w. Elec Wld & Engr—Jan. 2, 1904. No. 60081.

Testing Large Alternators. W. E. Burnand. Suggests a modification of a method by W. M. Mordey, published 11 years ago. The test is applied under almost the conditions of service. 1800 w. Elect'n, Lond—Jan. 15, 1904. No. 60389 A.

Voltameter.

Measurement of Current by Copper Voltameter. J. L. Dickson. Describes method. 400 w. Elec Wld & Engr—Jan. 16, 1904. No. 60259.

Wave Forms.

A Method of Photographing Alternat-

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ing-Current Wave Forms. C. J. Spencer. Illustrates and describes a modification of an oscillograph of the writer's construction, which employs an alternating current arc lamp as a source of light for the reflected photographing ray. 900 w. Elec Wld & Engr—Jan. 23, 1904. No. 60371.

A Wave Meter. Johannes Dönitz. From *Elektrotechnische Zeitschrift*. Discusses methods of measuring wave lengths in space telegraphy, describing instrument. Ill. 1500 w. Elect'n, Lond—Jan. 1, 1904. No. 60206 A.

Photographing Alternating-Current Wave-Forms with the New Duddell Oscillograph. Frank C. Perkins. Illustrated description of apparatus and its use. 1800 w. Elec Rev, N. Y—Jan. 2, 1904. No. 60011.

POWER APPLICATIONS.

Canal Traction.

Electric Haulage on the Teltow Canal, Germany (Elektrische Treidelei auf dem Teltow-Kanal). Illustrated description of electric locomotive and of electric towboat. 1000 w. Elektrotech Zeitschr—Dec. 31, 1903. No. 60437 B.

Cranes.

A New Line of Electric Traveling Cranes. Illustrates and describes the interesting features of special types recently made by the Case Mfg. Co. 1800 w. Ir Age—Jan. 7, 1904. No. 60046.

Elevators.

The Control of Electric Elevators (Commande des Ascenseurs Electriques). L. Ramakers. A description of the Siemens-Schuckert system, in which the movement of the car is controlled by push buttons, operated by the passenger without requiring special attendant. 2000 w. Génie Civil—Dec. 19, 1903. No. 60401 D.

Electric Baggage Elevators in the Railway Station at Reichenberg, Bohemia (Elektrische Lastenaufzüge am Banhofe in Reichenberg). W. Krejga. Illustrated description. 1500 m. Zeitschr f Elektrotechnik—Dec. 27, 1903. No. 60446 D.

Induction Motors.

The Choice of Air Gap Diameter for Induction Motors. H. M. Hobart. On induction-motor design, showing the very great percentage which the inductance of the end connections may form of the total inductance, and proposing a method by which the best proportions may be determined. 1000 w. Elec Wld & Engr—Jan. 23, 1904. No. 60372.

Machine Driving.

Electrically-Driven Shops. Report of Committees to Master Mechanics' Assn., giving general review of the systems and methods, with statistics and data derived. 10000 w. Ry & Engng Rev—Dec 14 & 26, 1903. Serial. 2 parts. No. 59936.

The Power Transmission and Speed Control System at the West Allis Works of the Allis-Chalmers Company. An illustrated article describing in detail the application of electric power throughout these large works. 2800 w. Engr, U S A —Jan. 1, 1904. No. 60077 C.

Mine Power.

Application of Electricity in the Anthracite Coal-Field of Pennsylvania, with special reference to the Wyoming Field. Discussion at the Albany meeting of the paper of H. H. Stoek and G. W. Harris. 600 w. Trans Am Inst of Min Engrs—Feb., 1903. No. 60510.

Electric Power in a Lothian Oil Mine Illustrated article describing applications of electric power in Scotland where oil is produced from shale. 2200 w. Elec Rev, N. Y—Jan. 16, 1904. No. 60231.

Printing Office.

The Government Printing Office—The Electrical Equipment of the Largest Printing Office in the World. Illustrated detailed description. 5000 w. Elec Wld & Engr—Jan. 2, 1904. No. 60080.

Pumping.

Belgian Electrical Mine Drainage Installation of the Societe Anonyme des Charbonnage Reunis de la Concorde. Frank C. Perkins. Describes a polyphase installation. 1500 w. Min Rept—Dec. 31, 1903. No. 59984.

Pumping by Electricity. F. H. Pitcher. Gives a brief description of Montreal Water and Power Company's system and growth, and of the electric pumps installed. Ill. 7000 w. Jour N E Water Wks Assn —Dec., 1903. No. 60337 F.

The Electric Pumping Plant of the Neu-Iserlohn II Mine (Die Elektrische Wasserhaltungsanlage auf Zeche Neu-Iserlohn II). H. Schulte. Data and results of tests of 500 h. p. electric pumping plant operating with a total head of 377 metres. 2000 w. Glückauf—Jan. 16, 1904. No. 60469 D.

Regulator.

Routin's Electro-Mechanical Compounding System (Das Elektromechanische Compoundirungssystem von Routin). F. Brock. Description, with diagram, of a system for governing dynamos driven by steam or water, in which the admission valve and the field excitation are simultaneously and instantaneously regulated. 1200 w. Elektrotech Zeitschr—Jan. 14, 1904. No. 60443 B.

New Regulating Arrangements for Direct-Current Electric Motors (Neue Regelungseinrichtungen für Gleichstrom-Elektromotoren). Joseph Löwy. Paper before the Vienna Elektrotechnischer Verein, describing several motor-regulating sys-

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tems and particularly one due to Josef Seidener, of Vienna. Diagrams. 3000 w. Zeitschr f Elektrotechnik—Dec. 20, 1903. No. 60444 D.

Single Phase.

Single-Phase Alternating-Current Motors, with Commutators (Die Einphasigen Wechselstrom-Kommutatormotoren, deren Entstehung, Arbeitsweise, Regelung und Vergleichende Kritik). M. Osnos. Illustrated comparative discussion of various types of these motors and their operation and regulation. Serial. 2 parts. 7000 w. Elektrotech Zeitschr—Jan. 7 and 14, 1904. No. 60439 each B.

Speed-Torque Characteristics of the Single-Phase Repulsion Motor. Walter I. Slichter. Results of tests of alternating-current motors with armature winding short-circuited on itself through commutator and brushes, which are well suited for railway service. Curve sheets. 1600 w. Trans Am Inst of Elec Engrs—Jan. 29, 1904. No. 60522 D.

The Alternating-Current Railway Motor. Charles P. Steinmetz. Theory of the single-phase repulsion motor, whose field constitutes a primary winding, and whose armature or secondary winding, is closed upon itself through a commutator. Diagrams. 4700 w. Trans Am Inst of Elec Engrs—Jan. 29, 1904. No. 60523 D.

The Alternating-Current Series Motor (Der Wechselstrom-Serienmotor). M. Osnos. Theoretical discussion, with diagrams. 4000 w. Zeitschr f Elektrotechnik—Dec. 27, 1903. No. 60445 D.

See also Street and Electric Railways.

South Africa.

Electricity in the South African Gold Mines. Sidney F. Walker. Describes a gold mine and the applications of electricity being made to its working. 2500 w. Elec Rev, N. Y—Jan. 16, 1904. No. 60232.

Speed Regulation.

Speed Regulation of Direct-Current Motors. H. H. Cutler. Considers the three systems in practical use, their advantages and disadvantages. Ill. 4000 w. Engr, U S A—Jan. 1, 1904. No. 60078 C.

Variable Speed Alternating-Current Motors. Walter I. Slichter. Considers the various types of motors and the methods of controlling them. 2000 w. Engr, U S A—Jan 1, 1904. No. 60079 C.

Steel Works.

Electrical Plant of the Lackawanna Steel Company. Illustrated description of an installation of especial interest in which both direct and alternating current are used. 6500 w. Elec Wld & Engr—Jan. 2, 1904. No. 60082.

TRANSMISSION.

High Tension.

High Tension Continuous-Current Power Transmission at 20,000 Volts. An illustrated article describing an installation for furnishing electric light and power for the Swiss town of Lausanne. 2700 w. Elect'n, Lond—Jan. 1, 1904. No. 60205 A.

Lightning Arresters.

Guard Wires for Transmission Lines. Alton D. Adams. Discusses systems both with and without guard wires, giving information from various sources. Also editorial. 5000 w. Elec Rev, N. Y.—Jan. 16, 1904. No. 60233.

Three-Phase.

Three-Phase Working, with Special Reference to the Dublin System. William Brew. Read before the Dublin Soc. of the Inst. of Elec. Engrs. The present article considers the generating plant. 800 w. Elec Engrs, Lond—Jan. 15, 1904. Serial. 1st part. No. 60388 A.

MISCELLANY.

Charges.

Method of Charging for Electrical Energy. Review of a paper by Ellis H. Crapper before the Leeds Local Sec. of the I. E. E. 1800 w. Elec Rev, Lond—Jan. 1, 1904. No. 60202 A.

Methods of Charging for Electrical Energy. Ellis H. Crapper. Read before the Leeds Sec. of the Inst. of Elec. Engrs. Discusses the nature of the business and the uniform meter rate, &c. 9000 w. Elec Engr, Lond—Jan. 15, 1904. No. 60387 A.

Discoveries.

The New Discoveries in Electricity. Antonia Zimmern. Reviews recent work tending to prove that electricity and light are essentially one, and the discoveries in the field of radio-activity. 4500 w. Nineteenth Cent—Jan., 1904. No. 60216 D.

Laboratories.

The New Electrical Laboratories of the Central Technical College. Joseph Griffin. Illustrated detailed description of a finely equipped laboratory. 1800 w. Elec Engr, Lond—Jan. 1, 1904. No. 60201 A.

Law.

Electrical Law in England and America. A comparison. W. Valentine Ball. 4800 w. Trac & Trans—Jan., 1904. No. 60293 E.

Reviews.

Electrical Progress on the Continent in 1903. Alfred Gradenwitz. A general review of the advance, especially in electric traction. Ill. 3800 w. W Elect'n—Jan. 2, 1904. No. 59959.

The Electrical Industry in Great Britain During 1903. General review. Ill. 4800 w. W Elect'n—Jan. 2, 1904. No. 59958.

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GAS WORKS ENGINEERING

Acetylene.

Principle of Acetylene Lamps. S. W. Rushmore. Discusses the principles involved in the operation of an acetylene headlight for automobiles. 1500 w. Automobile—Jan. 2, 1904. No. 59989.

Combined Plant.

A Combined Coal and Water Gas Plant. Illustrates and describes features in Walter R. Jones's patent. 2000 w. Jour Gas Lgt—Dec. 29, 1903. No. 60122 A.

Firebricks.

A New Source of Economy for Gas Works: Firebrick Making at the Crystal Palace District Gas Company's Works. From *Jour of Gas Lgt.* A short illustrated account of what is being done in this line at the works named. 1600 w. Am Gas Lgt Jour—Jan. 25, 1904. No. 60361.

Gaseous Firing.

Notes on Gaseous Firing. J. F. Smith. Read before the Yorkshire Jr. Gas Assn. An illustrated article reviewing the history of gaseous fuel, and the principle upon which gaseous firing is based, its practical working, &c. 7000 w. Am Gas Lgt Jour—Jan. 4, 1904. No. 59994.

Gaseous Fuels.

Gaseous Fuels for Power and Heating. H. Sherwood. A digest of recent knowledge of the use and production of gaseous fuels. 2000 w. Min & Sci Pr—Jan. 16, 1904. Serial. 1st part. No. 60367.

Gas Flow.

The Rational Character of the Experimental Law of Parenty (Rationalité d'une Loi Experimentale de M. Parenty). J. Boussinesq. A study of the agreement of experiment with theory of the flow of gases through orifices. 2500 w. Comptes Rendus—Jan. 4, 1904. No. 60413 D.

Mantle Burners.

Some Speculations on Mantle Burners. Dr. W. H. Birchmore. Discusses details to which inventors must give attention to produce a perfect burner, and the value of a knowledge of the laws of gases. 2800 w. Am Gas Lgt Jour—Jan. 4, 1904. No. 59993.

Producers.

Types of Gas Producers. Prof. A. Humboldt Sexton. Illustrated descriptions of various types. 2000 w. Mech Engr—Jan. 2, 1904. Serial. 1st part. No. 60124 A.

Stray Currents.

See Electrical Engineering, Measurement.

Sulphur.

Utilization of Sulphur in Gas-Works. Discusses old and new methods. 2000 w. Gas Wld—Jan. 16, 1904. No. 60385 A.

Sulphuretted Hydrogen.

Removal of Sulphuretted Hydrogen from Foul Gas Evolved in the Manufacture of Sulphate of Ammonia, Gas Liquors, etc. A report of this system and its advantages. The patent of H. W. Hemingway. 2000 w. Jour Gas Lgt—Dec. 29, 1903. No. 60121 A.

Water Gas.

Notes on the Operation of Large Carburetted Water Gas Sets. Discussion of a paper by W. Cullen Morris. 3000 w. Am Gas Lgt Jour—Dec. 28, 1903. No. 59933.

The Economic Admission of Steam to Water-Gas Producers of the Lowe Type. G. W. M'Kee. Read before the Canadian Soc. of Chem. Ind. Gives an account of experiments conducted in three water-gas machines. 2000 w. Gas Wld—Jan. 9, 1904. No. 60284 A.

INDUSTRIAL ECONOMY

American Trade.

The Development of American Trade. James Dredge. Begins a review of progress, giving diagrams, tables, and information of value. 8200 w. Trac & Trans—Jan., 1904. Serial. 1st part. No. 60291 E.

Apprentices.

The Mechanic of the Future and His Training. E. P. Watson. A comparison of the modern manual-training methods with the older apprenticeship system, showing the necessity for experience in the commercial shop. 4000 w. Engineering Magazine—Feb., 1904. No. 60471 B.

Automobile Industry.

Automobiles vs. Railways and Carriages. Translations from French papers and letters concerning the effect of automobiles on the carriage builders and the passenger business. 2000 w. U S Cons Repts, No. 1843—Jan. 6, 1904. No. 59987 D.

We supply copies of these articles. See page 1037.

Business.

Business (System des Geschäfts). Alexander Brauner. An address before the Vienna Elektrotechnischer Verein on modern commerce and business and their relations to engineering. 5000 w. Zeitschr f Elektrotechnik—Jan. 10, 1904. No. 60-449 D.

Coal Trade.

The Coal Trade of 1903. A review of the past year in the districts of England, Scotland and Wales. 16300 w. Col Guard—Jan. 1, 1904. No. 60126 A.

Coke Trade.

Coke in 1903. E. W. Parker. A record of the work in the principal producing states. 6000 w. Ir Age—Jan. 7, 1904. No. 60049.

Commercial Engineering.

The Commercial Side of Engineering. Walter M. McFarland. Discusses the effect of cost in engineering design, giving illustrations in various fields. 7800 w. Cassier's Mag—Jan., 1904. No. 60273 B.

Copper Industry.

The American Copper Industry. Horace J. Stevens. A review of the past year, the production, prices, &c. 2500 w. Ir Age—Jan. 7, 1904. No. 60052.

Cost Keeping.

The Cost Keeping System of Ludwig Loewe & Co., Berlin (Die Berechnung der Lohnkosten in der Fabrick von Ludwig Loewe & Co. A.-G. in Berlin). M. Chr. Elsner. Giving reproductions of the forms and the methods of using them for obtaining the flat factory cost of manufacture. 2000 w. Zeitschr d Ver Deutscher Ing—Jan. 9, 1904. No. 60422 D.

Education.

Engineering Training and the North-East Coast. Editorial on the work being done by the North-East Coast Institution of Engineers and Shipbuilders. 3000 w. Engng—Jan. 8, 1904. No. 60299 A.

How to Educate an Electrical Engineer. E. Kilburn Scott. An outline of the training necessary, and related matters. 6000 w. Page's Mag—Jan., 1904. No. 60271 B.

Problems for the Engineering School. James B. Stanwood. On the need of more practical education for engineers. 2700 w. Cassier's Mag—Jan., 1904. No. 60276 B.

The Technical High School and the Laboratory Question (Der Technische Hochschul-Unterricht und die Laboratoriumsfrage). Ludwig v. Teknajer. A review of the work of technical instruction in connection with the mechanical laboratory. 5000 w. Zeitschr d Oesterr Ing u Arch Ver—Jan. 8, 1904. No. 60428 D.

Estimates.

The Preparation of Estimates. The first of a series of articles in which it is proposed to analyze the reasons for the great disparity in the estimates given by different firms for the same work, and to study the conditions which would ensure more uniformity. 2800 w. Engr, Lond—Jan. 1, 1904. Serial. 1st part. No. 60129 A.

Iron Ore.

The Lake Ore Trade in 1903. Dwight E. Woodbridge. A review of the year, causes of abatement of demand, disappointment in explorations, shipments, &c. 2000 w. Ir Age—Jan. 7, 1904. No. 60055.

Iron Trade.

A Review of the Southern Iron Trade in 1903. James A. Green. A review by months of the record of the last year. 4400 w. Ir Age—Jan. 7, 1904. No. 60047.

Chicago Iron and Steel Trade in 1903. R. R. Shuman. A review of the past year and the outlook for 1904. 13500 w. Ir Age—Jan. 7, 1904. No. 60054.

Conditions Which Surround the Iron Producer in the United States and Great Britain Compared. George H. Hull. Begins a comparison of the manner of protecting against loss. 5000 w. Ir Age—Jan. 28, 1904.—Serial. 1st part. No. 60506.

Iron and Steel in 1903. Frederick Hobart. A review of production, consumption, progress, condition affecting the output, exports and imports, markets, &c. 10500 w. Eng & Min Jour—Jan 7, 1904. No. 60163.

The Philadelphia Iron Trade. Thomas Hobson. A review of the past year and a discussion of the prospects of the ensuing year. 5000 w. Ir Age—Jan. 7, 1904. No. 60051.

The Pittsburgh Iron Trade in 1903. Robert A. Walker. A review of the year, the general features, construction, price agreements, foreign trade, labor troubles, &c., considering also the outlook for 1904. 6500 w. Ir Age—Jan. 7, 1904. No. 60050.

Labor.

A Few Questions to the Rank and File of Laboring Organizations. Discusses points bearing on the motto "Equal Rights for All." 1200 w. Dom Engng—Dec. 25, 1903. No. 59931 C.

Labor Met by Its Own Methods. Isaac F. Marcosson. On the work of the Chicago Employers' Association. 3700 w. World's Work—Jan., 1904. No. 59963 C.

New Phase of the Labor Conflict. Discusses the encouraging outlook from the recent movements of organized employers. 2500 w. Gunton's Mag—Jan., 1904. No. 59962.

Laboratories.

Laboratory vs. Shop. Robert H. Smith.

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A reply to a criticism of Prof. M. P. Higgins, explaining the difference between the laboratory method of teaching and the shop method. 2200 w. Am. Mach—Jan. 21, 1904. No. 60312.

Machinery Trade.

New Conditions in the Machinery Business—Must the Locomotive Go? H. H. Lane. Discusses the effect on this business of the use of electric power. 2000 w. Am Mach—Dec. 31, 1903. No. 60001.

Penalties.

The Penalty Clause in Engineering Contracts. W. Valentine Ball. A clear statement of the law relating to penalties, with examples from numerous cases and decisions. 3500 w. Engineering Magazine—Feb., 1904. No. 60476 B.

Persia.

New Highway of Commerce in Persia. Concerning improved facilities for communication and circulation of traffic. 1600 w. U. S. Cons Repts, No. 1841—Jan. 4, 1904. No. 59961 D.

Peru.

Mining and Railway Development in Peru. G. Fred. Collins. A handsomely illustrated account of the country and its commercial possibilities, suggesting the expansion which will follow the opening of the Panama canal. 3000 w. Engineering Magazine—Feb., 1904. No. 60478 B.

Piece Work.

Piece Work, Premium and Bonus Systems. Harrington Emerson. Contribution to the discussion of a paper by Mr. Frank Richards, read at Dec. meeting of the Am. Soc. of Mech. Engrs. 2000 w. R R Gaz—Jan. 15, 1904. No. 60256.

Review.

1903—A Retrospect. Editorial review of the past year in the fields of civil, mechanical, electrical engineering, gas and water supply, chemistry, war material and metallurgy. 28000 w. Engr, Lond—Jan. 1, 1904. No. 60134 A.

Steel Trade.

A Short History of German Dumping. A review of recent events in the iron and steel trade of Germany. 1500 w. Ir & Coal Trds Rev—Jan. 8, 1904. Serial. 1st part. No. 60305 A.

Tin Plates.

An Interesting Year in Tin Plates and Sheets. B. E. V. Luty. A review of the past year, the technical progress, advances, relations with labor, &c. 5000 w. Ir Age—Jan. 7, 1904. No. 60053.

MARINE AND NAVAL ENGINEERING

Battleships.

H. M. S. Hindustan. Illustration, with description of vessel and equipment. 1000 w. Engr, Lond—Jan. 1, 1904. No. 60131 A.

The Chilian Battleship "Libertad." A full illustrated description of this battleship, which was recently purchased by the British Government, including the equipment, armament and report of trials. 20500 w. Engng—Jan. 15, 1904. No. 60501 A.

Cruisers.

New Japanese Armored Cruisers "Kasaga" and "Niasin." Illustrated description of two cruisers built for Argentina, but purchased by Japan. 1000 w. Sci Am—Jan. 23, 1904. No. 60324.

Cunard.

Position of the Cunard Steamship Co. Considers in detail the position of this company which has recently been granted a large subsidy by the British Government. 3000 w. Marine Rev.—Dec. 31, 1903. No. 59988.

Docks.

New Pontoon Dock and Floating Workshop for Natal. Brief illustrated description. 400 w. Sci Am Sup—Jan. 23, 1904. No. 60327.

Ferry House.

New Lackawanna Ferry House at Twenty-third Street, New York. Illustrates and describes a new ferry house to be built at West Twenty-third street, New York. 500 w. R R Gaz—Jan. 15, 1904. No. 60254.

Floating Dock.

The Durban Floating Dock and Workshop. Illustrated description of the 8,500-ton floating dock just completed for this port. 1200 w. Sci Am—Jan. 2, 1904. No. 60073.

Ice Breakers.

Great Lakes Ice-Crushing Car Ferries. An illustrated article giving information concerning the interesting vessels in the service of the great railways, and the conditions they have to conquer. 1800 w. Marine Rev—Jan. 21, 1904. No. 60362 C.

Marine Propulsion.

Marine Propellers with Non-Reversible Engines and Internal Combustion Engines. Rankin Kennedy. Calls attention to other propellers than the screw, and considers various methods of employing the screw propeller. Ill. 4700 w. Trans Inst of Engrs and Shipbuilders—Nov. 24, 1903. No. 59951 D.

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Railroad Ferry.

Steam Railroad Ferry Between Gjedser and Warnemuende. Illustrations, with description, of the two large ferryboats of the Mecklenburg government, used for transferring cars between the points named. 1000 w. Sci Am Sup—Jan. 9, 1904. No. 60136.

Sailing Vessels.

The Rigging of American Sailing Vessels. Fred. M. Cook. Illustrates and describes various rigs used for sailing vessels. 2500 w. Marine Engng—Jan., 1904. No. 60100 C.

Salving.

Salving the Hutchinson. An illustrated account of a remarkable rescue of a vessel on the Great Lakes. 3000 w. Marine Rev—Dec. 24, 1903. No. 59930.

Shipbuilding.

Shipbuilding and Marine Engineering, 1903. Begins a review of the year just ended. 4000 w. Engng—Jan. 1, 1904. Serial. 1st part. No. 60210 A.

Shipyards.

Shipyard Economies. R. S. Hubbard. Considers the practical economies of ship construction under the headings of labor, labor control, organization, plant and materials. 3400 w. Marine Engng—Jan., 1904. Serial. 1st part. No. 60101 C.

Speed Launches.

Engineering a High-Speed Launch. Herbert L. Towle. A non-technical explanation of the process by which motors of unusual power have been developed for boat use. 2000 w. Automobile—Jan. 2, 1904. No. 59990.

Submarine.

Early Attempts at Submarine Navigation. Notes from a recent work by Alan H. Burgoyne, giving particulars of the work of early inventors in this field. 1800 w. Sci Am Sup—Jan. 9, 1904. No. 60137.

The Lake Submarine Torpedo Boat "Protector." An illustrated article outlining the main features of this boat. 2500 w. Sci Am—Dec. 26, 1003. No. 59943.

Tug.

Twin-Screw Tug for the Isle of Wight Steam-Packet Company. Illustrated description of a tug which can also be used for salvage purposes and for extinguishing fires. 300 w. Engng—Jan. 1, 1904. No. 60211 A.

MECHANICAL ENGINEERING

AUTOMOBILES.

Accumulators.

Useful Hints and Tips on Recharging Accumulators. Deals with method, cost, and current taken in the present number. 900 w. Autocar—Dec. 26, 1903. Serial. 1st part. No. 60114 A.

Aluminum Bodies.

Rushing Metal Body Work on Show Cars. An illustrated article describing the rapid work done in some of the factories in making aluminum bodies for the cars to be on exhibition at Chicago and New York. 3000 w. Automobile—Jan. 16, 1904. No. 60219.

Automobile Industry.

See Industrial Economy.

Carburation

The Principles of Automatic Carburation. Translation of an article from the French by Henri Walcker. 2500 w. Autocar—Jan. 9, 1904. No. 60280 A.

Carbureters.

Some 1904 French Carbureters. Ed. Vrard, in *La Vie Automobile*. Illustrates and describes some inproved types exhibited at the Paris show. 1000 w. Automobile—Jan. 16, 1904. No. 60221.

The Prunel Automatic Carburettor. Illustrated description of a small bicycle type carburettor recently brought out. 1200 w. Auto Jour—Jan. 2, 1904. No. 60198 A.

Fuel.

Benzol as a Motor Fuel. Discusses the nature of benzol, its efficiency, advantages, &c. 2800 w. Autocar—Jan. 16, 1904. No. 60381 A.

Manufacture.

The Manufacture of Automobiles. An illustrated description of interesting features of manufacture as carried out in the plants at Detroit and Lansing, Mich., of the Olds Motor Works. 1400 w. Sci Am—Jan. 9, 1904. No. 60135.

Military Tractor.

A Triumph for Heavy Oil. Illustrates and describes the Hornsby heavy oil military tractor, giving facts in regard to its operation, and the conditions it was required to meet. 2000 w. Auto Jour—Jan. 9, 1904. No. 60279 A.

Motor Cars.

The Hallamshire Cars. Illustrates and describes details of one of these cars. 1000 w. Autocar—Jan., 1904. No. 60115 A.

Motors.

The Petrol Engine—Its Working Explained. A simple illustrated description

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The Selbach "Single-Valve" Petrol Motor. Brief illustrated description of an engine having a combined inlet and exhaust valve, which is operated by one cam, and is fitted into the cylinder head. 800 w. Auto Jour—Dec. 26, 1903. No. 60116 A.

New York Show.

Tendencies Embodied in the Exhibits. Hugh Dolnar. Review of the 1904 New York Show, calling attention to the developments of the past year and noting the present tendencies. 3000 w. Automobile Jan. 23, 1904. No. 60517.

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The Brouhot Petrol Cars. Illustrates and describes the latest 4-cylinder models. 1400 w. Auto Jour—Jan. 16, 1904. No. 60383 A.

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The Spyker Petrol Cars. Illustrates and describes recent designs of these touring cars. 1800 w. Auto Jour—Jan. 2, 1904. No. 60197 A.

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The Continuous Automobile Train (Le Train Automobile à Propulsion Continue). Col. G. Espitallier. An illustrated description of the Renard train, in which the power is transmitted by shafting with universal joints, through the whole train. 2500 w. 1 plate. Génie Civil—Dec. 19, 1903. No. 60400 D.

Reliability Trial.

An Alpine Automobile Reliability Trial. From *The Car*. An account of a trip in a Martini car up and down Rochers de Naye, in Switzerland. Ill. 2000 w. Sci Am Sup—Dec. 26, 1903. No. 59946.

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A Substantial Steam Car. Illustrated description of the Simpson cars. Pleasure vehicles of 6 or 12 h. p., a simple type of engine, steam supplied by a flash generator heated by a paraffine burner. 1500 w. Autocar—Jan. 16, 1904. No. 60380 A.

Features of Four-Cylinder Locomobile. Illustrates and describes details of this four-cylinder touring car, showing recent improvements. 2000 w. Automobile—Dec. 26, 1903. No. 59929.

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Water Supply and Drainage Systems in the Lorraine Hotel, New York. Illustrates and describes interesting details of systems used in a thirteen-story apartment hotel. 2500 w. Eng Rec—Jan. 9, 1904. No. 60189.

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The Steam Hydraulic Plant of the Virginia Passenger & Power Company, Richmond, Va. Illustrated description of new features introduced in this enlarged plant, especially the new type of dam, and a rack-cleaning mechanism for clearing the intakes of obstructions. 2500 w. Eng Rec—Jan. 2, 1904. No. 60060.

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Great Modern Turbine Installations. (Grosse Moderne Turbinenanlagen). L. Zodel. With especial reference to the work of Escher, Wyss & Co., including the plant of the Canadian Niagara Falls Power Company. Serial. Part I. 3000 w. Schweiz Bauzeitung—Jan. 2, 1904. No. 60458 B.

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MACHINE WORKS AND FOUNDRIES.

Boiler Tubes.

Manufacture of Seamless Cold-Drawn Steel Boiler Tubes. G. M. Kohler. Description of the process. Ill. 1700 w. Marine Engng—Jan., 1904. No. 60103 C.

Boring Tools.

A Spherical Boring Tool for the Drill Press. Louis W. G. Flynt. Illustrated description of a tool designed for the purpose of boring spherical holes in the ends of connecting rods. 1200 w. Am. Mach—Jan. 7, 1904. No. 60097.

Brass Furnaces.

The Wever Triplex Brass Furnace. Paul Wever. An illustrated description. 2000 w. Foundry—Jan., 1904. No. 59967.

Cable Works.

Messrs. W. T. Glover & Co.'s Cable Works, Manchester. Illustrated detailed description of extensive works for the manufacture of conductors of various descriptions. 6300 w. Engng—Jan. 1, 1904. No. 60208 A.

Cranes.

50-Ton Hydro-Electric Overhead Crane. Illustration, with brief description of cranes in use at Swindon. 350 w. Engr, Lond— Dec. 25 1903. No. 59082 A.

Some Recent Examples of German Crane Construction. Illustrates and describes wharf cranes, revolving cranes, derrick, hammer and other types. 2800 w. Ir and Coal Trds Rev—Dec. 25, 1903. No. 60120 A.

The Development of Crane Building in Germany (Die Entwicklung des Kranbaues in Deutschland). Heinr. Rupprecht. Showing how the use of English-built cranes in Germany has been largely superseded by machines of German design and construction. 2500 w. Oesterr Zeitschr f Berg u Hüttenwesen—Dec. 12, 1903. No. 60461 D.

Travelling Inverted Pillar Crane. Illustrated description of a new form of crane with novel features. 1000 w. Engr, Lond—Jan. 15, 1904. No. 60397 A.

See Electrical Engineering. Power Applications.

Crankshafts.

The Machining of Multiple-Throw Crankshafts. Illustrated description of the Tindel-Albrecht crankshaft lathe and its operation. 1000 w. Am Mach—Jan. 14, 1904. No. 60229.

The Machining of Single-Throw Crankshafts. Illustrates and describes special tools used for this work. 600 w. Am Mach—Jan. 7, 1904. No. 60095.

Die-Cutting.

Machines and Tools Employed for Die-Cutting. Joseph Horner. The first of a series of articles on machines for cutting forging dies. Ill. 2500 w. Engng—Jan. 1, 1904. Serial. 1st part. No. 60209 A.

Dies.

Bolt Heading Dies. Thomas Beasley. Directions for the making of these dies. 1400 w. Am Mach—Jan. 7, 1904. No. 60096.

Drawing Press.

The Adriance New Style Drawing Press. Illustrated description of features of this machine, intended for general drawing work. 1800 w. Ir Age—Jan. 21, 1904. No. 60310.

Electric Driving.

See Electrical Engineering, Power Applications.

Engine Building.

Modernization in Engine Building. Illustrated description of special tools used in the new plant of the Hooven-Owens-Rentschler Company. 3800 w. Ir Age—Jan. 7, 1904. No. 60041.

Engine Works.

The New Hamilton-Corliss Engine Works. An illustrated description of the rebuilt and greatly enlarged shops of the Hooven, Owens & Rentschler Co. at Hamilton, Ohio. 2500 w. Mach, N. Y.—Jan., 1904. No. 60056 C.

Gauges.

Gauges. Joseph M. Stabel. Discusses the construction of gauges, showing several styles and their uses. Ill. 1200 w. Am Mach—Jan. 14, 1904. No. 60230.

Grinding.

Grinding. Hints from an operator of experience. 3200 w. Am Mach—Jan. 21, 1904. No. 60314.

Points on Grinding. C. H. Norton. Gives a short study of the evolution of the grinding wheel and the grinding machine, and discusses the cause of chatters and troubles in rapid grinding. 2500 w. Am Mach—Jan. 7, 1904. Serial. 1st part. No. 60099.

Recent Progress in Cylindrical Grinding. C. H. Norton. On the rapid progress in this work during the last few years. 1500 w. Ir Age—Jan. 7, 1904. No. 60045.

The Norton New 14-Foot Grinding Machine. Illustrated description of this machine and its manipulation. 2800 w. Ir Age—Jan. 28, 1904. No. 60503.

Lathe.

An English Turret Lathe. Illustrated description of a lathe for general shop purposes, especially for handling bar work and castings and forgings. 800 w. Am Mach—Jan. 14, 1904. No. 60227.

Machine Rating.

Plan to establish a Machine Rating in a

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Locomotive Machine Shop, with Special Reference to New Tools. J. F. De Voy. Explains a system of card rating giving information relative to the number of cuts, length of time and movement of work to be performed. General discussion. 7500 w. Pro W Ry Club—Dec. 15, 1903. No. 60331 C.

Machinery Trade.

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Machine Tools.

Machine Tools and High Speed Steel. J. A. Carney. Considers the question of what shall be done with serviceable machines which cannot keep up with the high speed steel pace. General discussion. 4000 w. Pro W. Ry Club—Dec. 15, 1903. No. 60332 C.

Metal Drawing.

Drawn Bars of Round and Rectangular Sections. Amos Price. An illustrated description of the way round and other bars are made. 1500 w. Am Mach—Jan. 21, 1904. No. 60315.

Milling.

Some Milling Operations. A series of illustrations of rigs and fixtures for performing milling operations. 1500 w. Engr., Lond—Jan. 15, 1904. No. 60398 A.

Molding.

Molding a Slewing Crane Girder. Joseph G. Horner. Illustrates and describes the making of a large casting. 1500 w. Am Mach—Jan. 7, 1904. No. 60098.

Stripping Plates. P. R. Ramp. An illustrated article describing method of greatly reducing the cost of this work. 800 w. Foundry—Jan., 1904. No. 59968.

Planer Work.

Special Tools for Rapid Planer Work. E. E. Wood. Illustrates and describes devices for the rapid planing of lathe beds. 800 w. Am Mach—Jan. 14, 1904. No. 60226.

Pump Works.

The New Worthington Hydraulic Works at Harrison, N. J. Explains considerations that led to the removal of this plant from Brooklyn, and gives an illustrated detailed description of the new works. 2000 w. Eng News—Dec. 31, 1903. No. 60030.

Rapid Machining.

Rapid Machining of Crank Shafts. An illustrated article describing advanced methods employed at the Eddystone Works of the Tindel-Morris Company. 1700 w. Ir Age—Jan. 7, 1904. Serial. 1st part. No. 60042.

Rigs.

Arc Milling and Boring Rings. Gustave Fiedler. Illustrates and describes method adopted in doing work where convenient tools were wanting. 600 w. Am Mach—Jan. 14, 1904. No. 60228.

Running Fits.

Running Fit Limits. Henry Hess. Gives diagram and explanation of limits found to be well adapted to the manufacture of medium and heavy machine tools. 500 w. Am Mach—Jan. 21, 1904. No. 60311.

Saving Methods.

The Saving Methods for the Machine Shop. Frank F. Kleinhans. Describes a fixture for milling tool post wedges, the finishing up work from the screw machine; and a fixture for milling square head screws. Ill. 1400 w. Ir Trd Rev—Jan 7, 1904. No. 60087.

Sheet Metal.

Manufacturing Sheet Metal Shovel Handle. W. W. Patterson. Illustrated description of a difficult piece of work. 1000 w. Am Mach—Dec. 31, 1903. No. 60002.

Steam Turbine Discs.

The Design of Steam Turbine Discs. Frank Foster. A mathematical method for designing a wheel or disc capable of a very high speed of rotation. 1200 w. Engr, Lond—Jan. 8, 1904. No. 60304 A.

MATERIALS OF CONSTRUCTION.

Alloys.

Aluminum Bronze for Small Work. Walter J. May. Suggestions for making alloys that will give good results. 1000 w. Prac Engr—Jan. 1, 1904. No. 60196 A.

Iron and Steel Alloys. R. A. Hadfield. On the effect of various elements upon iron. 5200 w. Iron and Steel Met—Jan., 1904. No. 60347 D.

Cast Iron.

A Problem in the Metallurgy of Cast Iron. Dr. Richard Moldenke. How to overcome the dissolved oxide of iron found in the pig and scrap is discussed, and other difficulties. 1200 w. Ir and Steel Met—Jan., 1904. No. 60349 D.

Note on the Further Discussion of the Physics of Cast-Iron. William R. Webster. A list of the contributions to the *Transactions* bearing on this subject, since 1895. 600 w. Trans Am Inst of Min Engrs—Feb., 1904. No. 60514.

The Molecular Mobility of Cast Iron. Describes investigations made by Mr. Alexander E. Outerbridge on cast and wrought iron subject to repeated heating and cooling. 4000 w. Ill. Engng—Jan. 8, 1904. No. 60300 A.

Physical Structure.

The Physical Structure of Metals and

Alloys. J. J. Kessler, Jr. A brief illustrated study. 1500 w. Jour Assn of Engng Socs—Dec., 1903. No. 60343 C.

Steel.

Sixth Report to the Alloys Research Committee on the Heat Treatment of Steel. Sir William C. Roberts-Austen and Prof. William Gowland. 39 plates. 28 tables. 26800 w. Inst of Mech Engrs—Jan. 15, 1904. No. 60392 D.

Testing.

The Efforts Developed in Drop Testing Nicked Bars (Sur les Efforts Développés dans le Choc d'Eprovettes Entaillées). A. Pérot. Describing a device which draws automatic records of the forces exerted by a drop upon a test specimen. 800 w. Comptes Rendus—Dec. 14, 1903. No. 60412 D.

Tool Steels.

American Tests of Rapid Cutting Tool Steels. A report of tests made by the Lodge & Shipley Machine Tool Co. of Cincinnati, O. 2400 w. Ir Age—Dec. 31, 1903. No. 59097.

Wrought Iron.

Structural Changes in Wrought Iron. H. Stillman. Relates only to manufactured, rolled, or what is commercially known as fibrous wrought iron, giving reports of tests and results. Discussion. Ills. 10500 w. Pro Pacific Ry Club—Nov. 21, 1903. No. 59953 C.

MEASUREMENT.

Air Friction.

Preliminary Experiments on Air Friction. W. Odell. Read at Southport, before the British Assn. Gives an account of attempts to measure the power required to keep a plane circular disc rotating. 5000 w. Engng—Jan. 1, 1904. No. 60214 A.

Dynamometric Fan.

The Renard Dynamometric Fan for Measuring the Power of Gasoline Motors. Translated from *L'Automobile*, with an excerpt from the *Horseless Age*. Illustrated detailed description. 2800 w. Sci Am Sup—Dec. 26, 1903. No. 59947.

Heat Gauge.

The Morse Heat Gauge. Report of the Committee on Science and the Arts on the invention of Everett F. Morse. Ill. 1400 w. Jour Fr Inst—Jan., 1904. No. 60334 D.

Screw Threads.

A Microscope for Measuring Screw Threads. Illustrated description of instrument. 700 w. Am Mach—Jan. 21, 1904. No. 60313.

Measuring External Thread Diameters. Joseph M. Stabel. Describes a method of thread measurement by means of wires and micrometers, giving tables. 1600 w. Mach, N. Y.—Jan, 1904. No. 60057 C.

POWER AND TRANSMISSION.

Air Compressor.

Tests of the Köster Air Compressor (Mitteilungen über Versuche an einem Luft Kompressor mit Köstersteuerung). H. Terbeck. Tests of a compressor with mechanically operated valves, with indicator diagrams showing the valve action and efficiency. 5000 w. 1 plate. Glückauf—Jan. 2, 1904. No. 60467 D.

Apartment Houses.

The Power Plant and Mechanical Equipment of Apartment Houses. P. R. Moses. An account of the heating, lighting, refrigerating and general power and mechanical equipment of the large apartment house in America. 5000 w. Engineering Magazine—Feb., 1904. No. 60472 B.

Color Works.

The Machinery Plant of the New Leverkusen Color Works (Die Maschineneinrichtung des Neuen Werkes Leverkusen der Farbenfabriken vorm. Friedrich Bayer & Co. in Elberfeld). Describing especially the pumping machinery and the power plant. 4000 w. 2 plates. Zeitsch d Ver Deutscher Ing—Jan. 2, 1904. No. 60416 D.

Conveyors.

Conveyors and Ore Handling Appliances of the Iron Works at Elba (Transporteur Aerien et Grues de Déchargement de l'Usine Métallurgique d'Elba). E. Boucher. Illustrating the conveyors used on the docks at Elba for handling ore and coal. 1800 w. 1 plate. Génie Civil—Jan. 9, 1904. No. 60407 D.

Conveyors in Modern British Power Houses. Arch. J. S. B. Little. Describes improved methods of transporting materials in large power houses. Ill. 2000 w. St Ry Jour—Jan. 2, 1904. No. 60019 C.

Fuel Handling Machinery. Philip Dawson. An illustrated detailed description of machines and apparatus for mechanical handling. 4600 w. Trac & Trans—Jan., 1904. Serial. 1st part. No. 60295 E.

Modern Hoisting and Conveying Apparatus for Workshops (Moderne Hebe und Transportvorrichtungen für Hüttenwerke). H. Rupprecht. A review of modern cranes, cableways, bucket conveyors, etc., as applied to manufacturing establishments. Serial, Part I. 1000 w. Oesterr Zeitschr f Berg u Hüttenwesen—Jan. 2, 1904. No. 60465 D.

Haulage.

Cable Haulage for Transporting Marl to the Mills of the Bronson Portland Cement

We supply copies of these articles. See page 1037.

Co. Illustrated description of a haulage plant which works successfully from marl beds to mills, located at Bronson, Mich. 1500 w. Eng News—Jan. 21, 1904. No. 60318.

Speeds.

The Design of Speed Cones, Gears, &c., for Machine Tools. W. Owen. Shows how to give speeds in geometrical progression. Gives diagram for calculations, explaining its use. 1800 w. Mech Engr—Jan. 9, 1904. No. 60283 A.

SPECIAL MOTORS.

Alcohol.

Mechanical and Commercial Aspects of the Alcohol Motor. Henri Dupays. With numerous illustrations showing the use of alcohol in internal-combustion motors, and data and results of tests. 3500 w. Engineering Magazine—Feb., 1904. No. 60475 B.

Combustion Motors.

Lines of Progress in the Efficiency of the Combustion Motor. E. C. Warren. A discussion of the practicability of the constant pressure generator, and its applicability for driving rotary and other motors. 3500 w. Engineering Magazine—Feb., 1904. No. 60477 B.

Gas Engines.

The Gas Engine Situation in Europe. G. L. Carden. Brief descriptions of some of the high-power gas engines being made in Germany. Ill. 1500 w. Am Elect'n—Jan., 1904. No. 60106.

The Oechelhauser Gas Motor. A. Borsig. An illustrated detailed description of W. von Oechelhauser's two-stroke cycle motor. 1100 w. Am Elect'n—Jan., 1904. No. 60107.

The Vogt Gas-Engine. Herbert A. Humphrey. Illustrated description of a design of Adolf Vogt, and its working. 4200 w. Engng—Jan. 8, 1904. No. 60297 A.

Gasoline Motor.

Design for a Gasoline Motor. J. C. Brocksmith. Drawings and description of a high-speed enclosed crank-case type, used in automobile work and also for stationary purposes. 2000 w. Am Elect'n—Jan., 1904. No. 60110.

Gas Power.

Blast Furnace Gas as a Source of Power. An account, with illustrations, of the system developed by B. H. Thwaite, with letters in regard to reliability of the apparatus. 3000 w. Power—Jan., 1904. No. 60008 C.

Internal Combustion.

A Compression Combustion Motor (Moteur à Combustion par Compression). M. Cannevel. Describing a design for a gas or petroleum engine with compression ignition. 800 w. Comptes Rendus—Dec. 14, 1903. No. 60411 D.

American Internal Combustion Engines. An illustrated review of American gas and oil engine design. 12500 w. Am Elect'n—Jan., 1904. No. 60109.

STEAM ENGINEERING.

Boilers.

The Formula Used in Rules for the Inspection of Steam Boilers in British Columbia. J. A. Crawford. A criticism of the formulæ in these rules, pointing out inaccuracies. 1500 w. B C Min Rec—Jan., 1904. No. 60218 B.

The Inspection and Care of Steam Boilers. The first of a series of articles dealing with boiler inspector's work, defects, conditions of working, piping, &c., &c. 2200 w. Mech Engr—Jan. 2, 1904. Serial. 1st part. No. 60123 A.

Condensers.

Central Condensing Systems. Louis R. Alberger. An illustrated detailed description of this system. 2200 w. Ir Age—Jan. 7, 1904. No. 60043.

The Condenser Plant at Glasgow Electric Power Station. Illustrated description. 1000 w. Power—Jan., 1904. No. 60009 C.

Tubing a Condenser. Joseph G. Horner. Illustrates and describes a method of tubing a surface condenser made for a small horizontal engine. 600 w. Am Mach—Dec. 31, 1903. No. 60000.

Engines.

When an Engine Becomes a Pump. W. H. Wakeman. Describes conditions that make this possible. 1600 w. Elec, N. Y—Jan. 6, 1904. No. 60038.

Heat Transference.

Heat Transference Through Boiler-Plates. From *Zeitschrift des Vereins Deutscher Ingenieure.* An account of researches, giving diagrams. 2000 w. Engng—Jan. 1, 1904. No. 60207 A.

Large Units.

Problems in the Designing of Large Steam Units. Discusses modern methods and the enormous units in engines and turbines, considering especially boilers and superheaters and their limitations. 1800 w. Ir Age—Jan. 7, 1904. No. 60044.

Mechanical Stokers.

The Failure of Mechanical Stokers in India. Information from the report of Mr. Frederick Groves, as to the causes of the failure of types used in India. 1100 w. Engr, Lond—Jan. 1, 1904. No. 60133 A.

Oil Burning.

Oil Burning Utilities and Futilities.

We supply copies of these articles. See page 1037.

Amanda T. Jones. Reviews the tables of the Naval Bureau's Liquid Fuel Board, and gives the writer's conclusions. 2600 w. Engr, U S A—Jan. 15, 1904. No. 60269 C.

Smoke Prevention.

Smoke Prevention by Admission of Air Above the Fire (Rauchvermeidung durch Zuführung von Luft ueber dem Feuer). A. Dosch. With illustration of a form of grate adapted to admit heated air to aid in the combustion of the gases. 2500 w. Zeitschr d Oesterr Ing u Arch Ver—Jan. 1, 1904. No. 60426 D.

Steam Turbines.

High Power Westinghouse-Parsons Steam Turbines. Illustrated description of a 5000-kilowatt turbo-generating unit of extreme compactness. 2000 w. Eng Rec.—Jan. 2 1904. No. 60064.

Superheating.

Comparative Experiments with Saturated and Moderately Superheated Steam in Locomotives (Vergleichende Versuche mit Gesättigtem und Mässig Ueberhitztem Dampf au Lokomotiven). H. Strahl. Data and results of tests on the Prussian State Railways, showing fuel economies of 10 to 12 per cent. by superheating. 5000 w. Zeitschr d Ver Deutscher Ing—Jan. 2, 1904. No. 60418 D.

Superheated Steam. F. J. Rowan. Discussion of this paper. Ill. 4700 w. Trans Inst of Engrs & Shipbuilders—Nov. 24, 1903. No. 59949 D.

Superheated Steam for Steam Engines. Bryan Donkin. An illustrated article considering a number of types of superheaters and giving facts in regard to the Schmidt system. 2400 w. Cassier's Mag—Jan,, 1904. No. 60275 B.

The Specific Heat of Superheated Steam (Ueber die Spezifischen Wärmen des Ueberhitzten Wasserdampfes). Dr. Weyrauch. An exhaustive examination of the relation of the specific heat of steam to temperature and pressure, with formulas and tables for its determination. Two articles. 5000 w. Zeitschr d Ver Deutschr Ing—Jan. 2, 9, 1904. No. 60419 each D.

The Total Heat of Superheated Steam (Die Erzeugungswärme des Ueberhitzten Wasserdampfes). Dr. A. Griessmann. An experimental study of the properties of superheated steam, with especial reference to the specific heat at various temperatures. Two articles. 7500 w. Zeitschr d Ver Deutscher Ing—Dec. 19, 26, 1903. No. 60415 each D.

The Use of Superheated Steam. Prof. Storm Bull. Reviews the history of its use, and describes the arrangements of superheater, with respect to the boiler, the difficulties, with tests of engines under superheated steam, various types, &c. General discussion. 10500 w. Jour W Soc of Engrs—Dec., 1903. No. 60342 D.

Valve Gears.

Duplex Valve Gear, London and North-Western Railway. Illustrated description, with diagrams, of Whale's valve gear. 500 w. Engr, Lond—Jan. 8, 1904. No. 60303 A.

Improvements in Valve-Gears. John Riekie. Discussion of this paper. 2700 w. Trans Inst of Engrs and Shipbuilders—Nov. 24, 1903. No. 59950 D.

Valves.

Suyden's Combined Stop and Isolating Valve. Illustrates and describes a valve which closes automatically in both directions in case of accident. 1200 w. Engng —Jan 1, 1904. No. 60213 A.

Reducing Valves. R. T. Strohm. Gives illustrated description of the construction and operation of three different types of reducing valves. 1800 w. Am Elect'n—Jan., 1904. No. 60113.

Water-Softeners.

An inquiry into the Working of Various Water-Softeners. C. E. Stromeyer and W. B. Baron. Explains the behavior of various impurities, the difficulties to be overcome, and gives illustrated descriptions of many water-softeners, showing the suitability of the various types for special purposes. 16200 w. Inst of Mech Engrs—Dec. 18, 1903. No. 59948 D.

MISCELLANY.

Aeronautics.

Recent Progress in the Construction of Air Ships (Die Neueren Versuche über die Fortbewegung von Luftschiffen). Col. Buchholtz. With special reference to the recent dirigible balloons of Santos-Dumont, Severo, Bradsky and Lebaudy. 3000 w. Glasers Annalen—Jan. 15, 1904. No. 60455 D.

The Barton 150 Horse-power Airship's Forthcoming Trial. Illustrates and describes novel features of the improved airships. 1800 w. Sci Am—Jan. 16, 1904. No. 60247.

The Possibility of Sustaining a Flying Machine in the Air (Sur la Possibilité de Soutenur en l'Air un Appareil Volant). Ch. Renard. A discussion of the practicability of using screw propellers to lift a machine in the air, using motors of existing weight and power. 1000 w. Comptes Rendus—Nov. 23, 1903. No. 60409 D.

The Properties of Self-Supporting Propellers (Sur la Qualité des Hélices Sustentatrices). Ch. Renard. A discussion of the design and proportions of screw propellers of aerial support and propulsion. 1200 w. Comptes Rendus—Dec. 7, 1903. No. 60410 D.

We supply copies of these articles. See page 1045.

The Dirigible Balloon "Ville de Paris" (Le Dirigeable "La Ville de Paris"). Col. G. Espitallier. A description of the large dirigible balloon recently built for M. Deutsch in Paris by M. Victor Tatin. The gas bag is 58 metres long and 8.20 metres diameter, and the motor is of 63 horsepower. 1800 w. Génie Civil—Dec. 26, 1903. No. 60404 D.

Heating.

A New System of Hot-Water Heating. Illustrates and describes a quick circulating hot-water heating system having new and interesting features; developed by a firm in Vienna, Austria. 2300 w. Met Work—Jan. 2, 1904. No. 60013.

Low Pressure Hot Water Heating on the Reck Circulator System. C. I. Haden. Read in London, at meeting of the Inst. of Heat. and Ven. Engrs. An illustrated description of the apparatus of a system largely used on the Continent. 5400 w. Dom Engng—Dec. 25, 1903. No. 59932 C.

The Battery System of Warm Air Heating. C. E. Oldacre. Read at N. Y. meeting of Am. Soc. of Heat. and Ven. Engrs. Illustrated description of an installation in a suburban house. 2500 w. Met Work—Jan. 23, 1904. No. 60350.

Mechanical Plant.

Ventilation and Heating in the Penobscot County Court House, Bangor, Maine. Explains the requirements and the scheme adopted. Ill. 1800 w. Eng. Rec—Jan 2, 1904. No. 60065.

Moisture.

The Necessity of Moisture in Heated Houses. R. C. Carpenter. Read at N. Y. meeting of Am. Soc. of Heat. and Ven. Engrs. On the effects of dry air and means of maintaining a constant degree of humidity. 2500 w. Met Work—Jan. 23, 1904. No. 60351.

Temperature.

The Temperature of Flames (Sur la Temperature des Flammes). Ch. Féry. Giving the results of recent determinations of the temperatures of flames of illuminating gas, in various fumers, hydrogen, acetylene, etc., by a new spectroscopic method. 1500 w. Comptes Rendus—Nov. 30, 1903. No. 60408 D.

MINING AND METALLURGY

COAL AND COKE.

Coal Trade.

See Industrial Economy.

Collieries.

The Mechanical Engineering of Collieries. T. Campbell Futers. The present article is introductory to a discussion of the mechanical engineering of modern mines, with all the recent improvements, and also of the yet unsolved problems. 1000 w. Col Guard—Jan. 1, 1904. Serial. 1st part. No. 60127 A.

Colorado.

The Book Cliff Coal Mines. Prof. Arthur Lakes. Illustrated description of coal seams near Grand Junction, Colorado, which exhibit interesting peculiarities in their locations and formations. 2500 w. Mines & Min—Jan., 1904. No. 60007 C.

The Development of a New Coal Field in Colorado. L. B. Merriam. Describes coal development work at Tercio, Cuatro, and vicinity. 7000 w. Jour W Soc of Engrs—Dec., 1903. No. 60339 D.

The Yampa Coal Fields. Prof. Arthur Lakes. An illustrated description of the anthracite, bituminous and lignite field traversed by the Moffat road in Routt County, Colorado. 1800 w. Mines & Min—Jan., 1904. No. 60004 C.

Coke Trade.

See Industrial Economy.

Peat.

Peat as an Article of Fuel. Extracts from a paper by J. Campbell Morrison, read before the Robert Fulton Assn., of the Nat. Assn of Engrs. Gives information of interest and describes the three most successful systems of making peat briquettes. 2500 w. Am. Archt—Dec. 26, 1903. No. 59937.

Review.

Coal in 1903. Samuel Sanford. Reviews the developments of the principal coal fields of the world during the last year. Also brief reports from various districts in the United States. 8500 w. Eng & Min Jour—Jan. 7, 1904. No. 60164.

Washing.

Coal Screening and Washing Plant at a German Colliery. Illustrated detailed description of a plant at the Dahlbusch Colliery. 1600 w. Col Guard—Jan. 8, 1904. No. 60296 A.

COPPER.

Converter Process.

Smelting Copper by the Converter Process (Die Kupfergewinnung mit Hilfe des Konverter-Prozesses). Gustav Kroupa. A review of the experience with the converter in copper smelting, with an examination of the chemical reactions. Two articles. 4000 w. Oesterr Zeitschr f Berg u Hüttenwesen—Dec. 12, 19, 1903. No. 60460 each D.

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Copper Industry.

See Industrial Economy.

Deposits.

Cananea Revisited. Robert T. Hill. Describes the geography, geology and copper deposits of these mountains on the Mexican border of Arizona. 8000 w. Eng and Min Jour—Dec. 31 1903. No. 60022.

Copper Deposits at Clifton, Arizona. From Waldemar Lindgren's contribution to the United States geological survey. Describes the geological features and the deposits. 2500 w. Min Rept—Dec. 31, 1903. No. 59985.

The Geology and Copper-Deposits of Bisbee, Arizona. F. L. Ransome. Abstract of an official report of a detailed geological study of this region. Ill. 7500 w. Trans Am Inst of Min Engrs—Feb., 1903. No. 60508 C.

Power Plant.

The Power Plant of the Moctezuma Copper Company at Nacozari, Sonora, Mexico. John Langton. States the conditions to be considered in determining the kind of power, and gives an illustrated description of the power house, gas house, method of making gas, quality, quantity and records of the gas engines installed. 7400 w. Trans Am Inst of Min Engrs—Oct., 1903. No. 60507 C.

Refining.

A Laboratory Study of the Stages in the Refining of Copper. H. O. Hofman, C. K. Green and R. B. Yerxa. An account of investigations, with illustrations. 5000 w. Trans. Am Inst of Min Engrs—Oct., 1903. No. 60513 C.

Review.

Copper in 1903. Approximate estimates of production with reports from the leading copper districts, explaining local conditions. 5500 w. Eng and Min Jour—Jan. 7, 1904. No. 60146.

Smelting.

Improvements in Cheap Copper Matting for British Columbia. Ronald C. Campbell-Johnston. States the conditions and suggests improvements in the smelting, and describes a furnace designed by the writer. 2000 w. Min & Sci Pr—Jan. 9, 1904. No. 60266.

The Canadian Copper Company's Plant at Copper Cliff. An illustrated description of a 1,000-ton smelter, stating the conditions to be met. 1500 w. Eng and Min Jour—Dec. 31, 1903. No. 60025.

GOLD AND SILVER.

Alaska.

The Mining Industry in Alaska. Alfred H. Brooks. Reports of production and the activity of the various districts, giving map and illustrations. 4800 w. Eng & Min Jour—Jan. 14, 1904. No. 60234.

Assaying.

Assaying and Gold Refining. Donald Clark. Information on the work connected with assaying and with special auriferous material. Ill. 3000 w. Aust Min Stand—Dec. 10, 1903. Serial. 1st part. No. 60281 B.

The Assaying of Silver-Gold Bullion. H. B. Kaeding. Describes a method adopted by the writer and found to give good results. 1400 w. Min & Sci Pr—Dec. 26, 1903. No. 59996.

British Columbia.

British Columbia. S. S. Fowler. A review of the production of gold, silver, copper and lead during 1903, with general information. 2500 w. Eng & Min Jour—Jan. 7, 1904. No. 60152.

California.

California. Charles G. Yale. A review principally of the gold and silver production for 1903, with general information. 1700 w. Eng & Min Jour—Jan. 7, 1904. No. 60159.

The Cuyrmaca Mountain Mining Region of San Diego County, California. Prof. Arthur Lakes. An illustrated description of gold mining and arrastra amalgamation in Southern California. 2700 w. Mines & Min—Jan., 1904. No. 60005 C.

Colorado.

Colorado. Forbes Rickard. A review of mining conditions during 1903, showing a falling off in the output, due to labor troubles. Reports of various districts are given in detail. 3500 w. Eng & Min Jour—Jan 7, 1904. No. 60160.

Cyanidation.

Cyanidation in the United States. Chas. H. Fulton. Reviews improvements introduced during 1903 which are being tested at various mills. 3500 w. Eng & Min Jour.—Jan. 7, 1904. No. 60157.

Testing Ores for Cyanide Treatment. R. Stuart Browne. Remarks on the value of laboratory work and on the tests for cyanide treatment. 1800 w. Min & Sci Pr—Jan. 2, 1904. Serial. 1st part. No. 60168.

Dredging.

Gold Dredging. F. Winter Taylor. Describes the methods used, types of dredges, &c. Ill. 2000 w. Eng & Min Jour—Jan. 14, 1904. No. 60237.

Idaho.

The Mining and Industrial Development of Central Idaho. Brief reports of the various mining properties, showing progress. 1000 w. Min Rept—Dec. 24, 1903. No. 59934.

Mexico.

The Mines of Santa Eulalia, Mexico.

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P. B. Aiken. Brief notes on the geology, history and character of the ore in these silver mines. 1200 w. Ill. Min & Sci Pr—Dec. 19, 1903. No. 59935.

Milling.

Milling of Silver Ores at Pachuca. Henry F. Collins. Abstract from paper on "Amalgamation and Other Wet Processes for Silver Ores in Mexico," read before the Inst. of Min. and Met., London. Describes the processes of treatment employed. 3500 w. Eng & Min Jour—Dec. 31, 1903. No. 60024.

Nevada.

Ore Deposits of Tonopah, Nevada. J. E. Spurr. Taken from report of U. S. Geol. Survey. Describes the character of the silver sulphide ores and the deposits. 1600 w. Min Rept—Jan. 7, 1904. No. 60165.

Precipitation.

A Development in Electrolytic Precipitation of Gold and Silver from Cyanide Solutions. E. M. Hamilton. Describes modifications in the Siemens-Halske process which have been developed by Charles Butters & Co., Ltd., in Mexico and the United States. 7000 w. Jour Chem, Met & Min Soc of S. Africa—Nov., 1903. No. 60287 E.

Production.

Production of Gold and Silver in the United States. T. A. Rickard. Tabulated statement of production and distribution with general review. 1000 w. Eng & Min Jour—Jan. 7, 1904. No. 60144.

The Gold and Silver Production of the World. T. A. Rickard. Reports the yield of the principal regions, reviewing conditions. 1500 w. Eng & Min Jour—Jan. 7, 1904. No. 60145.

South Africa.

The Transvaal. W. Fischer Wilkinson. Reports a steady expansion during 1903, giving tables showing the production and general information. 2500 w. Eng & Min Jour—Jan. 7, 1904. No. 60153.

United States.

Mining in the Southwest. William P. Blake. A brief review of mining development in Arizona, Nevada and Southern California, restricted to the precious metals and other ordinary metals with the exception of copper. 2400 w. Eng & Min Jour Jan. 7, 1904. No. 60158.

Western Australia.

Mining in Western Australia. A G. Charleton. A report of steady progress during 1903, with important deep level developments and discoveries. 2700 w. Eng & Min Jour—Jan. 7, 1904. No. 60154.

Metallurgical Progress in Western Australia. Alfred James. Reports a reduction of 25 per cent. in treatment costs at some of the mines, giving details; the success of the combination process, and general details. 1800 w. Eng & Min Jour—Jan 7, 1904. No. 60155.

Witwatersrand.

Mine Labor and Costs on the Witwatersrand. T. Lane Carter. Shows how reduction in cost of working these gold mines has been effected, and the conditions of native and white labor. 1000 w. Eng & Min Jour—Dec. 31, 1903. No. 60023.

Observations on the Metallurgical Practice of the Witwatersrand. Discussion of paper by Harry S. Denny. 11500 w. Jour Chem, Met & Min Soc of S. Africa—Nov., 1903. No. 60286 E.

IRON AND STEEL.

Billet Mill.

The Clairton Twenty-eight Inch Three-High Steel Billet Mill. Illustrates and describes a billet mill with improved housings, hydraulic lifting tables and electrically-driven rollers. 1000 w. Eng Rec—Jan. 2, 1904. No. 60059.

Blast Furnaces.

The Platz Method of Calculating Furnace Burdens. J. B. Nau. An explanation of the method of B. Platz, based on observations extending over several years. 3300 w. Ir Age—Jan. 28, 1904. No. 60504.

Charcoal Iron.

A New Charcoal Retort Plant. Ernst A. Sjöstedt. Illustrates and describes the plant of the Algoma Steel Co., at Sault Ste. Marie, Ont. 2000 w. Ir Age—Jan. 28, 1904. No. 60505.

Converters.

Side Blow Converters. N. Lilienberg. Read before the Philadelphia Found. Assn. Discusses the advantages and disadvantages, the construction, operation, &c. 6400 w. Ir Age—Jan. 14, 1904. No. 60224.

Electric Smelting.

See Electrical Engineering, Electrochemistry.

Fuels.

By-Product Oven Gas and Tar as Fuels for the Open-Hearth Furnace. David Baker. Gives the experience at the works of the Dominion Iron & Steel Co., Sydney, Cape Breton. 1200 w. Ir & Steel Met—Jan., 1904. No. 60348 D.

Iron Industry.

See Industrial Economy.

Lake Superior.

The Lake Superior Iron Region. Report of production during the past year, with general information of exploration work, systems of mining, and related matters. 3000 w. Eng & Min Jour—Jan. 14, 1904. No. 60228.

Rails.

The Manufacture of Iron and Steel Rails in Western Pennsylvania. James M. Swank. Extracts from an article in the *Penn. Mag. of Hist. & Biog.* A review of the early history of rail manufacture. 2000 w. Ir Age—Jan. 21, 1904. No. 60309.

Steel Industry.

See Industrial Economy.

Steel Plant.

The Largest Steel Plant in the World. An illustrated detailed description of the great undertaking of the Lackawanna Steel Company, at Buffalo, N. Y. 12800 w. Ir Age—Jan. 7, 1904. No. 60048.

The New Plant of the Lackawanna Steel Company, at South Buffalo. An illustrated detailed description of this mammoth plant, noting the novel features in construction and equipment. 12300 w. Ir Trd Rev—Dec. 31, 1903. No. 59999.

See Also Mechanical Engineering, Materials.

MINING.

Accidents.

Fatal Accidents in Metal Mining in the United States. Frederick L. Hoffman. Gives information concerning the number of accidents in different years, discussing the causes so far as ascertained. 1800 w. Eng & Min Jour—Jan. 14, 1904. Serial. 1st part. No. 60235.

Alaska.

Mining Opportunities in Alaska. Jno. D. McGillivray. Information concerning the climate and conditions affecting mining and transport, the returns for 1903, and facts of interest. 1800 w. Min & Sci Pr—Jan. 9, 1904. No. 60265.

Alluvial Mining.

Deep Alluvial Mining. D. H. Browne. An illustrated article giving practical hints and descriptions of methods which have been employed in the mines of New South Wales, Australia. 3800 w. Mines & Min—Jan., 1904. No. 60006 C.

Appliances.

Improved Mining Appliances in Belgian Collieries. A Marcette, in *Annales des Mines de Belgique*. An illustrated article considering method of deepening a pit from below, movable stage for lining a shaft, mono-rail haulage, &c. 1800 w. Col Guard—Dec. 24, 1903. No. 60119 A.

Australia.

The Eastern States of Australia. F. Danvers Power. A report of the output from Queensland, New South Wales, South Australia, and Tasmania, with information of conditions during 1903. 3300 w. Eng & Min Jour—Jan. 7, 1904. No. 60156.

Development.

Development and Operation of a Mine. W. H. Storms. An illustrated article discussing economic methods to meet certain conditions, and the magnitude of recent mining operations. 1600 w. Min & Sci Pr—Dec. 26, 1903. Serial. 1st part. No. 59995.

Electric Power.

See Electrical Engineering. Power Applications.

Explosion.

Explosion in Compressed Air Pipes at Aberberg Colliery, Monmouthshire. R. Jordan. An account of this explosion and the damage, discussing the cause, and the precautions to avoid explosions. 2500 w. Ir & Coal Trds Rev—Jan. 8, 1904. No. 60307 A.

Explosives.

Experimental Galleries for Testing Explosives in Germany and Belgium. Brief description with illustrations of the installations at Gelsenkirchen, and at Frauseries, near Mons, constructed for testing safety lamps and explosives. 1100 w. Col Guard—Jan. 15, 1904. No. 60393 A.

Improvements in Explosives and Igniters (Neuerungen im Spreng und Zündmittelwesen). Describing recent methods of increasing safety in handling high explosives. 1200 w. Glückauf—Jan. 16, 1904. No. 60470 D.

The Progress of the Technology of Explosives since the Development of Organic Chemistry (Der Fortschritt der Spreugtechnik seit der Entwickelung der Organischen Chemie). Prof. W. Will. Abstract of an address before the Deutsche Chemische Gesellschaft, giving a review of modern explosives. 1100 w. Zeitschr f Elektrochemie—Jan. 1 1904. No. 60450 G.

Landslip.

The Landslip in the Hansa Mine, near Dortmund (Die Gebirgsschiebung in den Beiden Schächten der Zeche Hansa bei Dortmund). H. Dill. An account of the deformation in two deep shafts by the action of an underground landslip. 2500 w. Glückauf—Dec. 26, 1903. No. 60466 D.

Mexico.

Mining in Mexico. Jas. W. Malcolmson. A review of the development during the last year. 3200 w. Eng & Min Jour—Jan. 7, 1904. No. 60150.

Mine Power.

The Power Plant of the Wilczek Mines (Uebereinige Betriebseinrichtungen beim Gräflich Wilczekschen Bergbau). J. Mauerhofer. Describing the hauling and winding machinery, also the automatic operation of the doors controlling the ventilation, etc. 2000 w. 1 plate. Oesterr Zeit-

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schr f Berg u Hüttenwesen—Jan. 9, 1904. No. 60465 D.

Mining.

The Mining of Non-Metallic Minerals. Bennett H. Brough. The first of a series of lectures. The present number deals with combustible minerals, the coals and bitumens. Ill. 6400 w. Jour Soc. of Arts—Dec. 25, 1903. Serial. 1st part. No. 60040 A.

Montana.

Montana. William A. Akers. A review of the mining industry during 1903. 2000 w. Eng & Min Jour—Jan. 7, 1904. No. 60161.

New Territory.

The Outlook for Mining in the New Territory Opened Up by the San Pedro, Los Angeles & Salt Lake Railroad. M. S. Duffield. A report of information gained during an eight months' trip through the proposed route. 2000 w. Eng & Min Jour—Jan 21, 1904. Serial. 1st part. No. 60363.

Ontario.

Ontario. Thomas W. Gibson. A review of the progress of the mining industry during 1903. 1800 w. Eng & Min Jour—Jan. 7, 1904. No. 60151.

Ore Deposits.

The Brown Iron Ore Deposits of the Kisel District in the Ural (Ueber die Brauneisensteinlagerstätten des Bergrevieres von Kisel im Ural). L. Mrazec and L. Duparc. A geological account of important iron ore deposits in the vicinity of Soltkamsk, in the Government of Perm, Russia. Two articles. 4500 w. Oesterr Zeitschr f Berg u Hüttenwesen—Dec. 19, 26, 1903. No. 60462 each D.

Theories of Ore Deposition Historically Considered. S. F. Emmons. Presidential address before the Geological Society of America. A review of the theories advanced to explain the occurrence and origin of ores. 3000 w. Eng & Min Jour—Jan. 21, 1904. No. 60365.

Production.

Metal and Mineral Production of the United States in 1903. Tabulated estimates and statistics of the year's production. 2500 w. Eng & Min Jour—Jan. 7, 1904. No. 60143.

Safety.

Safety Devices for Inclined Planes (Appareils de Sécurité pour Plans Inclinés). H. Schmerber. Describing various forms of locks, brakes and automatic safety catches used in the mines of Austria. Two articles. 3500 w. Génie Civil—Dec. 26, 1903; Jan. 2, 1904. No. 60403 each D.

Sand Removal.

Methods of Removing Sand at the Wilczek Mines in Polnisch-Ostrau (Mitteilungen aus der Praxis des Schlammversatzverfahrens auf dem Gräflich Wilczekschen Dreifaltigkeitschachte in Polnisch-Ostrau). J. Mauerhofer. Describing the method of removing the sand without choking the pipes. 2000 w. 1 plate. Oesterr Zeitschr f Berg u Hüttenwesen—Jan. 2, 1904. No. 60464 D.

Shaft Fittings.

Iron Shaft Fittings with Cage Guides on One Side. F. Schulte in *Glückauf*. Illustrated description of fittings in use in several pits in the Dortmund district. 800 w. Col Guard—Jan. 15, 1904. No. 60394 A.

Shaft Sinking.

The Deepening of the Shafts of the Wintershall Mine, near Heringen (Das Abtenfen des Schachtes der Gewerkschaft Wintershall bei Heringen an der Werra). H. Klose. Describing the use of the Tomson hoisting method for deepening shafts through water-bearing strata. 2000 w. Glückauf—Jan. 9, 1904. No. 60468 D.

Sulphides.

The Delprat or Salt-Cake Process for Mixed Sulphides. Donald Clark. Explains several processes for the recovery of sulphides from their ores. 800 w. Eng & Min Jour—Jan. 21, 1904. No. 60366.

Tombstone.

Tombstone and Its Mines. William P. Blake. Notes on recent developments in the Tombstone District, Arizona. 900 w. Trans Am Inst of Min Engrs—Oct., 1903. No. 60511.

Transport.

Underground Handling and Transport of Ore. Charles B. Saner and George Carter. Considers the conveying of the broken ore to levels, and transport of ore to shaft-loading stations. Chiefly in reference to the Rand. 5000 w. Jour Chem, Met & Min Soc of S. Africa—Nov., 1903. No. 60285 E.

Utah.

Utah. Jas. W. Neill. An account of the mining progress during 1903, with reports of various camps. Ill. 2200 w. Eng & Min Jour—Jan. 7, 1904. No. 60162.

Valuation.

The Valuation of a Well-Developed Mine. A. W. Warwick. Discusses methods and gives formulæ for calculating values. 2800 w. Min Rept—Dec. 31, 1903. No. 59986.

Water-Hoisting.

Water-Hoisting in the Pennsylvania Anthracite Region. R. V. Norris. A discussion of this paper at Albany meeting. 1200 w. Trans. Am Inst of Min Engrs—Feb., 1903. No. 60509.

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MISCELLANY.

Asphalt.

The Asphalt Deposits of San Valentino in Italy (Die Asphalt grauben von San Valentino in Italien). An account of the working of these important deposits in the Abruzzi, Italy. 1500 w. Oesterr Zeitschr f Berg u Hüttenwesen—Dec. 26, 1903. No. 60463 D.

Bitumen.

Bitumen and Oil Rocks. G. C. Broadhead. Gives theories regarding oil formation, and considers prospecting, oil zones, and some of the remarkable districts. 3000 w. Am Geol—Jan., 1904. No. 60076 D.

Lead.

Lead in 1903. W. R. Ingalls. The production in the United States is reported by districts, with brief reviews of the lead markets of New York and London. 5000 w. Eng & Min Jour—Jan. 7, 1904. No. 60147.

Tin.

Losses in Vanning Tin Ores. Richard Pearce. Describes experiments made with a view to determining approximately the accuracy of the ordinary process of vanning. 900 w. Eng & Min Jour—Jan. 21, 1904. No. 60364.

Tin in 1903. Mainly a review of the New York and London markets. 2500 w. Eng & Min Jour—Jan. 7, 1904. No. 60149.

Tin in the York Region, Alaska. Arthur J. Collier. Gives results of a trip made to investigate the resources of this region. One tin ledge was found and other minerals of value. Ill. 1500 w. Eng & Min Jour—Dec. 31, 1903. No. 60021.

Zinc.

Progress of the Zinc Industry in Missouri During 1903. Frank Nicholson. Report of the production, comparing with previous years, and discussing features of the industry. 1500 w. Eng & Min Jour—Jan. 14. 1904. No. 60236.

Zinc in 1903. W. R. Ingalls. A report of the zinc business in the United States for the year, with review of the New York and London markets. 6000 w. Eng & Min Jour—Jan. 7, 1904. No. 60148.

RAILWAY ENGINEERING

CONDUCTING TRANSPORTATION

Express Trains.

The Origin of British Express Trains. W. B. Paley. A brief review of this feature of British railroading. 1500 w. R R Gaz—Jan. 8, 1904. No. 60194.

Foreign Practice.

Impressions of Foreign Railroad Practice. The first of a series of articles giving an interesting discussion of transportation methods. The present article considers English operation. 2700 w. Am Engr & R R Jour—Jan., 1904. Serial. 1st part. No. 60104 C.

Train Services.

British and French Train Services in 1903. Charles Rous-Marten. A review of the general character and tendency of the principal train services of Great Britain and France. 4000 w. Engr, Lond—Jan. 8, 1904. No. 60302 A.

MOTIVE POWER AND EQUIPMENT.

Air-Brakes.

How Air-Brake Tests Are Made. An illustrated article describing how modern brake trials are made and data secured. 6000 w. Loc Engng—Jan., 1904. No. 60094 C.

Car Heating.

Car Heating by Steam Mixed with Air; Eastern Railway of France. Translated from *Revue Generale des Chemins de Fer.* Illustrated description of system in use. 800 w. Eng News—Dec. 31, 1903. No. 60028.

The Heating System of the Eastern Railway of France (Chauffage des Trains du Réseau de l'Este). H. Guérin. An account of the practical operation of the Lancrenon system, using a combination of steam and compressed air. 2000 w. 1 plate. Génie Civil—Jan. 2, 1904. No. 60406 D.

Cars.

50-Ton Steel Underframe Box Car. Illustrated description of cars intended for grain traffic, built for the Illinois River Packet Co. 600 w. R R Gaz—Jan. 1, 1904. No. 60071.

Special Saloon for Royal Train, London and North-Western Railway. Illustrated detailed description. 900 w. Engng—Jan. 15, 1904. No. 60502 A.

The Development of Steel Freight Cars in the United States. A review of the situation, with editorial discussion. 8500 w. Eng News—Jan. 7, 1904. No. 60139.

Vestibule Stock Car. Illustrated description with statement of advantages claimed. 600 w. Loc Engng—Jan., 1904. No. 60092 C.

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High Speed.

The Design of Locomotives and Motor Cars to Attain High Speeds (Die Gestaltung der Lokomotiven und Einzelfahrzenge zur Erreichung Hoher Fahrgeschwindigkeiten). Albert Frank. A discussion of the resistances to be overcome at high speeds, and the corresponding influences upon design and construction. 3000 w. Zeitschr d Ver Deutscher Ing—Jan. 9, 1904. No. 60421 D.

Locomotives.

Baldwin Four-Cylinder Balanced Compound Locomotives for the Santa Fe. Illustrated detailed description, with data of tests. 1000 w. R R Gaz—Jan. 22, 1904. No. 60375.

Chesapeake & Ohio Eight-Wheel Switching Locomotive. An illustrated description of probably the heaviest switching locomotive ever built. 500 w. Ry Age—Jan. 22, 1904. No. 60369.

Compound Engines. Editorial Review of the development and the advantages. 2500 w. Loc Engng—Jan., 1904. No. 60091 C.

Curious Express Locomotive. From *The Locomotive Magazine.* Illustrated description of a suggested design, adapted from a Continental design introduced on the Southern Italian Ry. 600 w. Loc Engng—Jan., 1904. No. 60090 C.

Heavy Consolidation Locomotive, Lake Shore & Michigan Southern Ry. Illustrated description of an engine of the 2-8-0 type. 1500 w. Ry & Engng Rev—Jan. 2, 1904. No. 60088.

Heavy Tank Locomotive for the Great Northern Railway. Two-page plate and drawings of an engine for suburban traffic, with brief description. 700 w. Engng—Dec. 25, 1903. No. 60118 A.

Locomotive Operation. G. R. Henderson. The first of a series of articles discussing the various laws of mechanics which govern a locomotive in operation. 4000 w. Ry Age—Jan. 15, 1903. Serial. 1st part. No. 60264.

Locomotives for Special Service on British Railways. J. F. Gairns. With numerous illustrations of inspection, crane, works, and other special forms of locomotives. 3000 w. Engineering Magazine—Feb., 1904. No. 60473 B.

New Express Engines, North-Eastern Railway. Illustration, with particulars of four wheel coupled engines with leading bogie and a pair of carrying wheels under the fire-box. 800 w. Engr, Lond—Jan. 15, 1904. No. 60500 A.

Position of Reverse Lever on Piston Valve Engines. Jas. Spellen. Gives the writer's ideas on the proper handling of these engines. 1200 w. Loc Engng—Jan., 1904. No. 60089 C.

Prussian State Railway Locomotives. Quotations from the specifications dealing with the quality and testing of material used in building rolling-stock. 6500 w. Engng—Jan. 8, 1904. No. 60301 A.

Superheated Steam Freight Locomotives—Saxony State Railways. Charles R. King. Illustrated description of a recent design for heavy grades. 2000 w. R R Gaz—Jan. 8, 1901. No. 60195.

The Development of the Eight-Wheel Connected Engine on the Baltimore & Ohio Railroad. J. Snowden Bell. An illustrated historical review. 3000 w. Loc Engng—Jan., 1904. No. 60093 C.

The Turning Moments of Four-Cylinder Balanced Compound Locomotives. Calls attention to an error in an article by Edward L. Coster in the December issue of the *American Engineer.* Ill. 1000 w. R R Gaz—Jan. 1, 1904. No. 60066.

Motor Car.

Steam Motor Car for the Taff Vale Railway. Illustration and brief description of car which has been running for some time. 400 w. Engng—Jan. 8, 1904. No. 60298 A.

Railway Lighting.

The Economy of Compressed Acetylene Gas for Lighting Railway Cars, Stations and General Railway Lighting. E. G. Fisher. An explanation of this system and its advantages, with general discussion. 6300 w. Ill. Pro Iowa Ry Club—Nov. 17, 1903. No. 59952.

NEW PROJECTS.

Alaska.

Arctic Railway Building. George E. Walsh. Map and illustrated description of roads built and under construction in Alaska and account of the benefits already apparent. 2500 w. Cassier's Mag—Jan., 1904. No. 60277 B.

Brazil.

The Railroad Around the Falls of the Madeira River, Brazil. O. F. Nichols. Historical review of earlier attempts to open this rich district, and the project now under consideration. Map. 2500 w. R R Gaz—Jan. 1, 1904. No. 60070.

China.

Railways in South China. An interesting account of some engineering experiences in the construction of the Yuen Han Ry. 2200 w. Wisconsin Engr—Dec., 1903. No. 59966 C.

Relocation.

Relocation of the Central Massachusetts Railroad Around the Wachusett Reservoir. An illustrated description of heavy construction work on the new line made necessary by the construction of this

reservoir. 3000 w. Eng Rec—Jan 2, 1904. No. 60058.

Simplon Routes.

The Western Railway Connections to the Simplon Tunnel (Die Westlichen Zufahrts linien zum Simplon tunnel). H. Elskes. A comparison of existing routes, together with an examination of the possible modifications in railway systems of Switzerland and France, due to the opening of the tunnel. 2500 w. Schweiz Bauzeitung—Jan. 9, 1904. No. 60459 B.

Transcontinental.

Notes on Early Canadian Trans-Continental Railway Projects. Briefly reviews projects dating back nearly fifty years. 1800 w. Eng News—Jan. 21, 1904. No. 60317.

PERMANENT WAY AND BUILDINGS.

Rail Bonds.

Rail Bonds. W. E. Harrington. Calls attention to interesting features, bonds and methods employed recently, testing, and conclusions based on experience. Ill. 2000 w. Jour Fr Inst—Jan., 1904. No. 60335 D.

Shops.

Seaboard Air Line Shops at Portsmouth, Va. Illustrated detailed description of buildings built to replace those destroyed by fire. 1200 w. Ry Age—Jan. 15, 1904. No. 60263.

Signals.

A New Interlocking Machine; the Pneumatic Signal Co.'s All-Electric Machine. An illustrated description of a machine recently introduced. 3000 w. Eng News—Jan. 14, 1904. No. 60252.

Electric Interlocking for the Texas & Pacific Ry., at Texarkana. Illustrated description of an all-electric installation where there are many grade crossings. 3000 w. Ry & Engng Rev—Jan. 9, 1904. No. 60225.

Single Semaphore for Multiple Route Indication. An illustrated description of Annet's route indicating system. 800 w. Bul Int Ry Cong—Dec., 1903. No. 59972 E.

Snow Sheds.

Telescopic Snow Sheds on the Central Pacific. An illustrated article describing the conditions making snow sheds necessary, and the various designs that have been used, especially the recent telescopic sheds. 1200 w. R R Gaz—Jan. 22, 1904. No. 60376.

Station.

The New Bridgeport Station. Elevation, cross section, plan, and brief description of this new station on the N. Y., N. H. & H. R. R. On account of recent track elevation the train level will be at the second story. 500 w. R R Gaz—Jan. 22, 1904. No. 60374.

The New Southern Pacific Passenger Station at San Antonio, Tex. John D. Isaacs. Illustration, with brief description of a recent adaptation of the mission style of architecture. 600 w. Eng News—Dec. 31, 1903. No. 60026.

Terminals.

Design and Operation of Division and Tide-Water Terminals. C. L. Bardo. A discussion of inadequate yard facilities, and yard design, methods of switching and their efficiency, &c., successful operation of yards. General discussion follows. 1300 w. N Y R R Club—Dec. 18, 1903. No. 60330.

Wabash Terminals at St. Louis. Plans and description of arrangements at the World's Fair grounds. 1400 w. Ry Age—Jan. 22, 1904. No. 60368.

Tracks.

The Necessity for Track Improvement. Max Barschall. Discusses things affecting the strength and endurance of tracks, and the great need of improvements due to increased loads and speeds. 1000 w. R R Gaz—Jan. 1, 1904. No. 60069.

Track Plans for the Washington Union Station. Gives track plans which differ radically from the accepted standards for terminal station arrangement. 1600 w. R R Gaz—Jan. 15, 1904. No. 60255.

Tunnel Ventilation.

The Ventilation of Some Continental Tunnels. Begins an account of notable installations, showing what has been done on the Continent. 3000 w. Engr, Lond—Jan. 15, 1904. Serial. 1st part. No. 60396 A.

STREET AND ELECTRIC RAILWAYS

Alternating Currents.

Electric Traction with Alternating-Current. Editorial review of paper by A. C. Eborall. 2500 w. Engng—Jan. 1, 1904. No. 60212 A.

Belgium.

The Light Railways of Belgium (Die Belgischen Kleinbahnen). H. Pforr. A general review of the tramway and inter-urban railway systems of Belgium, with comparative diagrams showing the rate of growth. 3000 w. Glaser's Annalen—Jan. 1, 1904. No. 60453 D.

Brakes.

Brakes and Sand. Edward C. Boynton.

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Discusses arrangements for quickly stopping a car, and the value of sand properly applied. 1200 w. St Ry Jour—Jan. 2, 1904. No. 60018 C.

The Development of Railroad Braking. R. A. Parke. Abstract of paper read before the New England St. Ry. Club. A review of the development. 4800 w. St Ry Jour—Jan. 2, 1904. No. 60020 C.

The Westinghouse Electro-Magnetic Brake. Georges Lesourd. An illustrated description with examination of the advantages claimed. 3800 w. Bul Int Ry Cong—Dec., 1903. No. 59973 E.

California.

Electrical Equipment of the North Shore Railroad from San Francisco to San Rafael. Illustrates and describes a system of electric third-rail traction having many interesting features. 4000 w. St Ry Jour—Jan. 2, 1904. Serial. 1st part. No. 60014 C.

Chamonix.

The Chamonix Electric Railway. Archibald Wilson. An illustrated description of this short but interesting line. Water power and protected third-rail current supply. 2500 w. Cassier's Mag—Jan., 1904. No. 60272 B.

Economics.

Railway Economics. Hon. Robert P. Porter. A review of the Royal Commission, appointed for the purpose of inquiring into the problems of London locomotion. 8200 w. Trac & Trans—Jan., 1904. Serial. 1st part. No. 60292 E.

Electro-Pneumatic.

Arnold Single-phase Electro-pneumatic Railway System. Illustrated detailed description of the work of Bion J. Arnold in this field. 5700 w. W Elect'n—Jan. 2, 1904. No. 59957.

The Arnold-Electro-Pneumatic Railway System, Its Application and Experiments Therewith in Connection with the Lansing, St. John & St. Louis Railway. Illustrated detailed description of the single-phase electric traction system developed by Bion J. Arnold. 4000 w. Elec Rev, N. Y—Jan. 2, 1904. No. 60012.

Insulation.

Measurements of the Insulation of Trolley Wries (Isolationsmessungen am Fahrdraht bie Strassenbahnen). H. A. Mörk. Illustrated description of methods. 500 w. Elektrotech Zeitschr—Jan. 7, 1904. No. 60440 B.

Interurban.

Electric Interurban in Western New York. Illustrated detailed description of the recently completed line between Rochester and Canandaigua. 3800 w. St Ry Jour—Jan. 16, 1904. No. 60267 C.

Indianapolis and Northwestern Traction System. An illustrated description of the line between Indianapolis and Lafayette. 3200 w. St Ry Jour—Jan. 23, 1904. No. 60357 C.

Interurban Trolley Roads in Indiana. A study of the effect of the extensive interurban system around Indianapolis upon the business of steam roads, and the prosperity of the city and its surroundings. 3000 w. R R Gaz—Jan. 8, 1904. Serial. 1st part. No. 60193.

Rochester & Eastern Rapid Ry. Illustrated description of a high-speed electric interurban operating on its own private right of way. 2500 w. St Ry Rev—Jan. 20, 1904. No. 60379 C.

The Jackson & Battle Creek Railway. W. G. Fargo. Illustrates and describes a road in Southern Michigan, built mostly on private right of way, using third-rail system. 3000 w. St Ry Jour—Jan. 2, 1904. No. 60015 C.

The Muncie, Hartford & Ft. Wayne Ry. An illustrated description of route, construction, stations, rolling stock, &c., of a line in Indiana. 4000 w. St Ry Rev—Dec. 20, 1903. No. 59938 C.

Main Lines.

The Electrification of Railways (Ist der Bisher Eingeschlagene Weg, für unsere. Verkehrsmittel höhere Geschwindigkeiten zu Erreichen, der Reichtige?). A. Hecker. A discussion of the probable development of electric traction on German railways. 2000 w. Elektrotech Rundschau—Jan. 1, 1904. No. 60452 D.

Massachusetts.

The Massachusetts Electric Companies. Outlines the scheme for substituting a high-tension alternating-system. Also gives an illustrated description of the new Quincy Point steam-turbine power house. 5000 w. St. Ry Rev—Dec. 20, 1903. No. 59940 C.

Newcastle.

Electric Traction on the North-Eastern Railway. Illustrates and describes the equipment of the Newcastle local lines. 7500 w. Tram & Ry Wld—Jan 14, 1904. No. 60519 B.

N. Y. Central R. R.

Electric Power on the New York Central. Editorial discussion of some arguments that may have led to the adoption of direct-current apparatus. 2000 w. St Ry Jour—Jan. 9, 1904. No. 60190 C.

Performance.

Determination of the Performance of Electric Tramways in America (Bestimmung der Leistung von Elektrischen Bahnmotoren in den Vereinigten Staaten

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von Amerika). Fr. Gutbrod. An examination of the graphical methods of plotting railway performances by curves. Two articles, 8000 w. Zeitschr d Ver Deutscher Ing—Dec. 19, 26, 1903. No. 60414 each D.

Power House.

The Power House of the Interborough Rapid Transit Company, New York. Brief illustrated description prepared on the occasion of a recent visit of the Am. Soc. of Civ. Engrs. 2000 w. Eng Rec—Jan. 23, 1904. No. 60354.

Rail Joints.

Conditions Which Affect the Resistance of a Bonded Rail Joint. Charles R. Sturdevant. Discusses the four distinct resistances which makes up the total ohmic resistance. 2000 w. St Ry Rev—Dec. 20, 1903. No. 59941 C.

Rapid Transit.

The New York Rapid Transit Railway. Sydney W. Ashe. An interesting illustrated description of the route and construction of the New York Rapid Transit railway. 5000 w. W Elect'n—Jan. 2, 1904. No. 59956.

Review.

Electric Traction in 1903. Dr. Louis Bell. A review of the year's progress. 2000 w. Elec Rev, N. Y—Jan. 9, 1904. No. 60179.

Richmond, Va.

The Street Railway Systems of Richmond, Va. Illustrates and describes improvements due to a consolidation of interests. 5000 w. St Ry Jour—Jan. 2, 1904. No. 60016 C.

Rolling Stock.

The Rolling Stock of the Great Northern and City Railway. Illustrates and describes coaches to be used in the multiple-unit system. 700 w. Engr, Lond—Dec. 25, 1903. No. 59983 A.

Seattle.

The Stone & Webster Properties on Puget Sound. An illustrated article describing the lines of the Seattle Electric Co., their equipment, management, &c., 5700 w. St Ry Rev—Jan. 20, 1904. No. 60377 C.

Single Phase.

Single-Phase Car Equipment at East Pittsburg. Illustrates the truck and car in operation on the Interworks Railway of the Westinghouse Co. 800 w. St Ry Jour—Jan. 23, 1904. No. 60358 C.

Traction with Single-Phase Alternating-Current. Speed Regulation and Recovery of Energy (Traktion mit Einphasenstrom. Regelung der Geschwindigkeit und Wiedergewinnung von Arbeit). Marius Latour. Discussion of motor types and connections. Diagrams. 800 w. Elektrotech Zeitschr—Dec. 17, 1903. No. 60429 B.

Some Possibilities of the Alternating Current Single Phase Railway Motor. A. H. Armstrong. Abstract of a paper read before the Elec. Sec. of the Canadian Soc. of Civ. Engrs. A general discussion of the operation of steam lines by the alternating current railway motor. 3300 w. Can Elec News—Jan., 1904. No. 60217.

See Electrical Engineering, Power Applications.

Southport.

Electrification of the Southport Branch of the Lancashire and Yorkshire Railway. 3000 w. Tram & Ry Wld—Jan. 14, 1904. No. 60520 B.

Electrification of the Liverpool Southport Line. Interior and exterior views of the electric train, with brief account of the electrification of the line. 800 w. Engr, Lond—Jan. 1, 1904. No. 60132 A.

Stops.

The Effect of Frequent Stops in High-Speed Railroading. A. H. Armstrong. Showing that a stop in high-speed railroading is expensive and far-reaching in its results. 2000 w. St Ry Jour—Jan. 9, 1904. No. 60191 C.

Stray Currents.

Unscientific Electric Engineering: Destruction of Underground Pipes, etc. H. W. Spang. Discusses the defects of the engineering branch of electrical science, the destruction caused, and the remedy. 2500 w. Am Gas Lgt Jour—Jan. 18, 1904. No. 60257.

See Electric Engineering, Measurement.

Surface Contact.

The G. B. Surface-Contact System. An illustrated description of the principal details of this system, a trial line having been placed in operation in England. 2200 w. Elec Engr, Lond—Jan. 8, 1904. No. 60288 A.

Switzerland.

The Wetzikon-Meilen Electric Railway (Chemin de Fer Electrique de Wetzikon-Meilen). H. Somach. Describing the interurban trolley line between Meilen on the Lake of Zurich and a number of inland towns. The overhead wire is used, and Oerlikon equipment. 2500 w. 1 plate. Génie Civil—Dec. 26, 1903. No. 60402 D.

Zossen Experiments.

The High-Speed Electric Railway Experiments between Marienfelde and Zossen (Schnellbahnversuche Marienfeldezossen). Illustrated description of the Siemens-Halske car and the track and roadbed. 700 w. Elektrotech Zeitschr—Dec. 31, 1903. No. 60438 B.

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CARD INDEX.—These pages are issued separately from the Magazine, printed on one side of the paper only, and in this form they meet the exact requirements of those who desire to clip the items for card-index purposes. Thus printed they are supplied to regular subscribers of THE ENGINEERING MAGAZINE at 10 cts. per month, or $1.00 a year; to non-subscribers, 25 cts. per month, or $3.00 a year.

THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *t-m*, a tri-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the index are: Ill—Illustrated; W—Words; Anon—Anonymous.

Alliance Industrielle. *m.* Brussels.
American Architect. *w.* Boston.
American Electrician. *m.* New York.
Am. Engineer and R. R. Journal. *m.* New York.
American Gas Light Journal. *w.* New York.
American Jl. of Science. *m.* New Haven, U.S.A.
American Machinist. *w.* New York.
American Shipbuilder. *w.* New York.
Annales des Ponts et Chaussées. *m.* Paris.
Ann. d Soc. d Ing. e d Arch. Ital. *w.* Rome.
Architect. *w.* London.
Architectural Record. *qr.* New York.
Architectural Review. *s-q.* Boston.
Architect's and Builder's Magazine. *m.* New York.
Australian Mining Standard. *w.* Sydney.
Autocar. *w.* Coventry, England.
Automobile. *m.* New York.
Automobile Magazine. *m.* New York.
Automotor Journal. *w.* London.
Beton und Eisen. *qr.* Vienna.
Brick Builder. *m.* Boston.
British Architect. *w.* London.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bulletin American Iron and Steel Asso. *w.* Philadelphia, U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bull. Soc. Int. d Electriciens. *m.* Paris.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bull. Int. Railway Congress. *m.* Brussels.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Montreal.
Canadian Mining Review. *m.* Ottawa.
Cassier's Magazine. *m.* New York.
Central Station. *m.* New York.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Deutsche Bauzeitung. *b-w.* Berlin.
Domestic Engineering. *m.* Chicago.
Electrical Engineer. *w.* London.
Electrical Review. *w.* London.

Electrical Review. *w.* New York.
Electrical World and Engineer. *w.* New York.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electricity. *w.* New York.
Electrochemical Industry. *m.* New York.
Electrochemist and Metallurgist. *w.* London.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricita. *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Chicago.
Engineering. *w.* London.
Enginering and Mining Journal. *w.* New York.
Enginering Magazine. *m.* New York & London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Eng. Soc. of Western Penna. *m.* Pittsburg, U.S.A.

Fire and Water. *w.* New York.
Foundry. *m.* Cleveland, U. S. A.

Gas Engineers' Mag. *m.* Birmingham.
Gas World. *w.* London.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. Dei Lav. Pubb. e. d. Str. Ferr. *w.* Rome.
Glaser's Ann. f Gewerbe & Bauwesen. *s-m.* Berlin.

Ice and Refrigeration. *m.* New York.
Ill. Zeitschr. f. Klein u. Strassenbahnen. *s-m.* Berlin.
Ingenieria. *b-m.* Buenos Ayres.
Ingenieur. *w.* Hague.
Insurance Engineering. *m.* New York.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron and Steel Metallurgist. *m.* Boston.
Iron and Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland, U. S. A.

Jour. Am. Foundrymen's Assoc. *m.* New York.
Journal Asso. Eng. Societies. *m.* Philadelphia.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Journal of Sanitary Institute. *qr.* London.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery *b-m.* Fort Monroe, U.S.A.
Journal Western Soc. of Eng. *b-m.* Chicago.
Journal of Worcester Poly. Inst., Worcester, U.S.A.

Locomotive. *m.* Hartford, U. S. A.
Locomotive Engineering. *m.* New York.

Machinery. *m.* New York.
Madrid Cientifico. *t-m.* Madrid.
Marine Engineering. *m.* New York.
Marine Review. *w.* Cleveland, U. S. A.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Metal Worker. *w.* New York.
Métallurgie. *w.* Paris.
Minero Mexicano. *w.* City of Mexico.
Minerva. *w.* Rome.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci Press. *w.* San Francisco.
Mining Reporter. *w.* Denver, U. S. A.
Mittheilungen des Vereines für die Förderung des Local und Strassenbahnwesens. *m.* Vienna.
Modern Machinery. *m.* Chicago.
Mouvement Maritime. *w.* Brussels.
Municipal Engineering. *m.* Indianapolis, U. S. A.
Municipal Journal and Engineer. *m.* New York.

Nature. *w.* London.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Nineteenth Century. *m.* London.
North American Review. *m.* New York.

Oest. Wochenschr. f. d. Oeff Baudienst. *w.* Vienna.
Oest. Zeitschr. Berg- & Hüttenwesen. *w.* Vienna.
Ores and Metals. *w.* Denver, U. S. A.

Pacific Coast Miner. *w.* San Francisco.
Page's Magazine. *m.* London.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York
Pro. Canadian Soc. Civ. Engrs. *m.* Montreal.
Procedings Engineers' Club. *qr.* Philadelphia.
Pro. St. Louis R'Way Club. *m.* St. Louis, U. S. A.
Progressive Age. *s-m.* New York.

Quarry. *m.* London.
Queensland Gov. Mining Jour. *m.* Brisbane, Australia.

Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway & Engineering Review. *w.* Chicago
Review of Reviews. *m.* London & New York.
Revista d Obras. Pub. *w.* Madrid.
Revista Tech. Ind. *m.* Barcelona.
Revue de Mécanique. *m.* Paris.
Revue Gen. des Chemins de Fer. *m.* Paris.
Revue Gen. des Sciences. *w.* Paris.
Revue Industrielle. *w.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines. *m.* Liége.
Rivista Gen. d Ferrovie. *w.* Florence.
Rivista Marittima. *m.* Rome.

Schiffbau. *s-m.* Berlin.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Sibley Jour. of Mech. Engng. *m.* Ithaca, N. Y.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens' Institute Indicator. *qr.* Hoboken, U.S.A.
Stone. *m.* New York.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago.

Tijds. v h Kljk. Inst. v Ing. *qr.* Hague.
Traction and Transmission. *m.* London.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining. Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Trans. Inst. of Engrs. & Shipbuilders in Scotland, Glasgow.
Transport. *w.* London.

Wiener Bauindustrie Zeitung. *w.* Vienna.
World's Work. *m.* New York.

Yacht. *w.* Paris.

Zeitschr. d. Mitteleurop. Motorwagen Ver. *s-m.* Berlin.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochemie. *w.* Halle a S.
Zeitschr. f. Electrotechnik. *w.* Vienna.

CURRENT RECORD OF NEW BOOKS

NOTE—Our readers may order through us any book here mentioned, remitting the publisher's price as given in each notice. Checks, Drafts, and Post Office Orders, home and foreign, should be made payable to THE ENGINEERING MAGAZINE.

Boilers.

Steam Boilers, Their Theory and Design. By H. de B. Parsons, B. S., M. E. Size, 9 by 6 in.; pp. xii, 375; figures, 185. Price, $4. New York, London and Bombay: Longmans, Green, and Co.

Although there have been many books on steam boilers, the subject possesses perennial interest, and with the advance in methods of steam generation there must be a corresponding growth of its literature. The present work is founded on a series of lectures delivered to students at the Rensselaer Polytechnic Institute, where the author is professor of steam engineering, and it therefore necessarily is laid down on text-book lines, but it is more than a text-book, and will be found of service to the designing engineer and of great interest to all who wish to keep abreast of the modern developments in steam engineering. Many of the principal types of boilers, both fire-tube and water-tube, in use at the present day, are illustrated and described, and their respective advantages and defects set forth. One chapter contains accounts of the various kinds of solid, liquid and gaseous fuels, particular attention being given to fuel oil and the methods of burning it. Other sections of the book are devoted to materials of construction, boiler details and fittings, mechanical stokers, artificial draft, incrustation, corrosion, chimney design, smoke prevention, testing, and many more topics. Throughout the book there is much information concerning the latest standard rules and specifications, and many tables are given. An appendix contains descriptions of several styles of superheaters, and an index completes a very readable volume giving a comprehensive survey of modern boiler practice.

Commercial Register.

Hendricks' Commercial Register of the United States for Buyers and Sellers. Thirteenth Annual Edition. Size, 10 by 8 in.; pp. 1,226. Price, $6. New York: S. E. Hendricks Company.

With the growth of manufacturing and the increasing area of commercial transactions, it becomes more and more difficult for people with things to sell to locate all their possible customers and for buyers to know all their advantageous markets, so that a work like the present volume, which brings buyers and sellers into touch with each other, possesses a far-reaching interest and value. This book gives the names and addresses of the manufacturers and producers of practically everything that is made and produced in the United States. It also gives a list of the individuals and the firms engaged in the professions and trades connected with engineering in all its branches, architecture, construction, railroading, mining, plumbing, and similar lines of work. All the products, manufactures, trades and professions are arranged alphabetically, and when any section is large, it is sub-classified by States and by cities, with the names in each sub-division in alphabetical order. In the preparation of mailing lists covering any line of work, this book is invaluable, and it will prove of the greatest use to advertising men, manufacturers and business men, and, in fact, to everybody who has anything to buy or sell.

Engine Tests.

Engine Tests and Boiler Efficiencies. By J. Buchetti. Translated and Edited from the Third French Edition by Alexander Russell. Size, 8½ by 5½ in.; pp. xv, 255; figures, 179. Price, $3 (12s. 6d.). New York: Norman W. Henley & Co. London: Archibald Constable & Co.

It will be of interest to English-speaking engineers to compare the best Continental practice in engine and boiler testing with that in use in their own countries, and an excellent opportunity for making such a comparison is afforded by the present translation of M. Buchetti's standard work, "Guide pour l'Essai des Moteurs." In this book, the indicator receives especially full treatment, a great many forms of the instrument being illustrated and described, from the one designed by Watt to the latest external-spring, continuous-record, and optical indicators. The theory of indicators and the study of indicator diagrams have considerable attention given to them, as has also the subject of brake horse power, under which topic many styles of testing brakes are described. There is a chapter on the taking of indicator diagrams of oil and gas engines, and a note on steam-turbine testing. Other sections are de-

voted to the properties of steam, evaporation and a discussion of fuels, combustion, steam trials, and other subjects; and an appendix contains tables of the properties of steam, and other useful information and data.

Metric System.

The Metric Fallacy. By Frederick A. Halsey. The Metric Failure in the Textile Industry. By Samuel S. Dale. Size, 9 by 6 in.; pp. 231. Price, $1. New York: D. Van Nostrand Company.

We have here two separate treatises in one volume, both, however, bearing upon the same question: the present status of the metric system of weights and measures, especially the matter of measure of length. The first portion, that by Mr. Halsey, is the outgrowth of his paper presented before the American Society of Mechanical Engineers in December, 1902; while the second portion, due to Mr. Dale, is a critical analysis of the metric system with especial reference to the textile industry. The book is really the outcome of the effort of the Committee on Coinage, Weights, and Measures of the House of Representatives to secure the passage by Congress of a bill to make compulsory the use of the metric system in the various departments of the United States Government, with the exception of the completion of the survey of the public lands, Mr. Halsey having felt that unless some active demonstration were made against such action the bill might become law in default of any expression of adverse opinion on the part of the engineering profession. In this respect the book, with its preceding paper, has undoubtedly been a success. The testimony before the committee, which before Mr. Halsey's efforts had been largely in favor of the passage of the bill, has since that time been of a nature which has led the members of the committee to realize that some serious problems are certain to be created should it become law. Mr. Halsey shows the limited extent to which the metric system has obtained a practical working status in many countries usually counted in the metric ranks; while Mr. Dale gives a review of the extent to which old measures have persisted in the textile industries, even in France and Germany. Both portions of the work contain a mass of information concerning the facts in the case, most surprising to all who have given the question but passing attention, and of undoubted weight in connection with the consideration of the subject as a matter for legislation. Many things, which by repeated statement have come to be accepted as true about the general use of the metric system in countries in which it has been legalized, are shown to be altogether incorrect or overstated, and in the light of the investigation here made public many points in the older arguments need modification. The book should be in the hands of every one interested in the subject, and it cannot fail to have an important influence upon future attempts at compulsory legislation.

Reinforced Concrete.

Experimental Researches on Reinforced Concrete. By Armand Considère. Translated and Arranged by Leon S. Moisseiff, C. E. Size, 9 by 6 in.; pp. ix, 188; figures, 20. Price, $2. New York: McGraw Publishing Co.

Concrete-steel, or concrete strengthened by iron and steel, in various shapes, imbedded in it, has been extensively employed as a structural material in the past few years, and is finding new uses every day. The reinforcing material is applied in many ways, each "system" claiming special advantages, but most of the work hitherto has been of an empirical nature, and the scientific co-ordination of the whole subject had made but little progress before M. Considère began his investigations. His researches covered various forms of reinforced concrete, on which he made many experiments, and he afterwards worked out his theory of this material from his experimental determinations. The value of such a systematic investigation is shown not only by his theoretical results, but also by his discovery of the great advantages of hoops of metal in strengthening concrete columns and other members subjected to compressive stresses. M. Considère's researches began in 1898, and were communicated from time to time to the French Academy of Sciences, to the International Association for Testing Materials and to the *Génie Civil*. His papers have been translated into English by M. Moisseiff, and some of them published in the *Engineering Record*. They are now compiled in book form, and are arranged and classified so as to make a systematic treatise. The chapters follow, in general, the several papers in their chronological order, and are entitled: Reinforced Concrete in Bending; Deformation and Testing of Reinforced Concrete Beams; Effects of Changes in Volume of Concrete; Tensile and Compressive Resistance of Reinforced Concrete; Resistance of Concrete to Shearing and Sliding; Effect of Cracks on Stresses and Deformations; Compressive Resistance of Reinforced and Hooped Concrete. This work, embodying the results of practically the first systematic study of a material of such wide application by one of the world's foremost experimenters, is necessarily of the highest importance to all engineers and architects engaged in construction.

NEWS SUPPLEMENT

The Engineering Magazine—March, 1904

Coming Society Meetings.

AIR-BRAKE ASSOCIATION. Sec.: F. M. Nellis, 174 Broadway, New York. Annual meeting May 10, at Buffalo.

AMERICAN ELECTROCHEMICAL SOCIETY. Sec.; C. J. Reed, 929 Chestnut St., Philadelphia. Next meeting April 7 to 9, at Washington, D. C.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. Sec.: Ralph W. Pope, 95 Liberty St., New York. Next meeting, March 25, at Chemists' Club, 108 W. 55th St. Papers on High-Tension Transmission.

AMERICAN INSTITUTE, POLYTECHNIC SECTION. Sec.: George Whitefield, Jr., 19 W. 44th St., New York. Meetings on first and third Thursdays of each month, from October to May, inclusive.

AMERICAN RAILWAY ASSOCIATION. Sec.: W. F. Allen, 24 Park Place, New York. Next meeting, April 27, at New York.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION. Sec.: L. C. Fritch, Monadnock Block, Chicago. Annual meeting, March 15-17, at Chicago.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION. Sec.: J. W. Taylor, 667 Rookery, Chicago. Meeting, June 27-29, Saratoga Springs, N. Y.

AMERICAN SOCIETY OF CIVIL ENGINEERS. Sec.: C. W. Hunt, 220 W. 57th St., New York. Regular meetings, first and third Wednesdays of each month.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Sec.: Prof. F. R. Hutton, 12 W. 31st St., New York. Next meeting, May 31 to June 4, at Chicago.

ARCHITECTURAL LEAGUE OF AMERICA. Sec.: J. B. Nettleton. Next meeting, April or May, at Pittsburg.

BOSTON SOCIETY OF CIVIL ENGINEERS. Sec.: S. E. Tinkham, 715 Tremont Temple. Regular meetings on third Wednesday of each month, except July and August.

BROOKLYN ENGINEERS' CLUB. Sec.: J. Strachan, 191 Montague St. Regular meetings on second Thursday of each month. March 10, paper on "The Relation between Gas Corporations and Consumers," by H. S. Wynkoop.

CANADIAN MINING INSTITUTE. Sec.: B. T. A. Bell, Ottawa. Annual meeting March 2 to 5, at Toronto.

CANADIAN RAILWAY CLUB. Sec.: W. H. Rosevear, Jr., Montreal. Regular meetings on first Tuesday of each month, except June, July and August.

CANADIAN SOCIETY OF CIVIL ENGINEERS. Sec.: Prof. C. H. McLeod, 877 Dorchester St., Montreal. The General Section and the Electrical, Mechanical and Mining Sections meet on different Thursdays.

CENTRAL RAILWAY CLUB. Sec.: Harry D. Vought, 62 Liberty St., New York. Regular meetings on second Friday of January, March, May, September, and November, Hotel Iroquois, Buffalo.

CHICAGO ELECTRICAL ASSOCIATION. Sec.: W. B. Hale, Monadnock Building. Regular meetings on first and third Fridays of each month, from October to May.

CIVIL ENGINEERS' CLUB OF CLEVELAND. Sec.: Joseph C. Beardsley, 689 The Arcade. Regular meetings on second and fourth Tuesdays of each month.

CIVIL ENGINEERS' SOCIETY OF ST. PAUL. Sec.: G. S. Edmondstone. Regular meetings on second Monday of each month.

ENGINEERING ASSOCIATION OF THE SOUTH. Sec.: Robt. L. Lund, 2102 Hayes St., Nashville, Tenn. Regular meetings on second Thursday of each month at the Berry Block.

ENGINEERS' CLUB OF CHICAGO. Sec.: B. W. Thurtell, 1223 New York Life Building. Regular meetings on first and third Tuesdays of each month.

ENGINEERS' CLUB OF CINCINNATI. Sec.: J. F. Wilson, P. O. Box 333. Regular meeting on third Thursday of each month, except July and August.

ENGINEERS' CLUB OF COLUMBUS (OHIO). Sec.: H. M. Gates, 12½ North High St. Regular meetings on first and third Saturdays of each month.

ENGINEERS' CLUB OF MINNEAPOLIS. Sec.: Jas. B. Gilman, American Bridge Co. Regular meetings on third Monday of each month.

ENGINEERS' CLUB OF PHILADELPHIA. Sec.: J. O. Clarke, 1122 Girard St. Regular meetings on first and third Saturdays of each month, except July and August.

ENGINEERS' CLUB OF ST. LOUIS. Sec.: H. J. Pfeifer, 920 Rialto Bldg. Regular meetings on first and third Wednesdays.

ENGINEERS' SOCIETY OF WESTERN NEW YORK. Sec.: H. B. Alverson, 533 Ellicott Square, Buffalo. Regular meetings on first Tuesday of each month.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA. Sec.: Chas. W. Ridinger, 410 Penn. Ave., Pittsburg. Regular meetings on third Tuesday of each month.

FRANKLIN INSTITUTE. Sec.: Dr. Wm. H. Wahl, 15 South 7th St., Philadelphia. General meetings on third Wednesday of each month, except July and August. General section meetings every Thursday.

HONOLULU ENGINEERING ASSOCIATION. Sec.: G. F. Bush, Honolulu, Hawaii.

INTERNATIONAL ENGINEERING CONGRESS. Sec.: Charles Warren Hunt, 220 W. 57th St., New York. Meeting Oct. 3 to 8, at St. Louis.

IOWA RAILWAY CLUB. Sec.: P. B. Vermillion, Des Moines, Iowa. Regular meetings on third Tuesday of each month.

LOUISIANA ENGINEERING SOCIETY. Sec.: G. W. Lawes, 806 Gravier St., New Orleans. Regular meetings on second Monday of each month.

MASTER CAR BUILDERS' ASSOCIATION. Sec.: J. W. Taylor, 667 Rookery, Chicago. Meeting, June 22-24, Saratoga Springs.

MONTANA SOCIETY OF ENGINEERS. Sec.: Clinton H. Moore, Butte, Mont. Regular meetings on second Saturday in each month.

NATIONAL ELECTRIC LIGHT ASSOCIATION. Sec.: Ernest H. Davis, 136 Liberty St., New York. Annual convention in May, at Boston.

NEW ENGLAND RAILROAD CLUB. Sec.: Edw. L. Janes, Back Bay P. O., Boston. Regular meetings, second Tuesday in each month, except June, July, August and September, at Pierce Hall, Copley Square.

NEW ENGLAND WATER WORKS ASSOCIATION. Sec.: Willard Kent, Tremont Temple, Boston. Next meeting, March 10, at Boston.

NEW YORK ELECTRICAL SOCIETY. Sec.: Geo. H. Guy, 114 Liberty St., New York. Meetings monthly, on different Wednesdays, at the American Institute, 19 W. 44th St.

NEW YORK RAILROAD CLUB. Sec.: F. M. Whyte, Grand Central Station, N. Y. City. Regular meetings on third Friday of each month, except June, July and August, at Carnegie Hall, 154 W. 57th St., New York.

NEW YORK STREET RAILWAY ASSOCIATION. Sec.: W. W. Cole, Elmira. Annual meeting, Sept., at Utica.

NORTH-WEST RAILWAY CLUB. Sec.: T. W. Flannagan, Minneapolis, Minn. Regular meetings on first Tuesday after second Monday of each month, except June, July and August, alternating between Minneapolis and St. Paul.

PACIFIC COAST ELECTRICAL TRANSMISSION ASSOCIATION. Sec.: Geo. P. Low, 237 Cherry St., San Francisco. Annual convention, third Tuesday in June. Intermediate meetings subject to call.

PACIFIC COAST RAILWAY CLUB. Sec.: C. C. Borton, West Oakland, Cal. Regular meetings on third Saturday of each month at San Francisco and other cities.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS. Sec.: Prof. M. Roberts, Seattle, Wash. Meetings monthly in Chamber of Commerce rooms, Seattle.

RAILWAY CLUB OF PITTSBURG. Sec.: J. D. Conway, P. & L. E. R. R., Pittsburg, Pa. Regular meetings on fourth Friday of each month, except June, July and August, at Hotel Henry.

RAILWAY SIGNAL ASSOCIATION. Sec.: B. B. Adams, 83 Fulton St., New York. Regular meetings on second Tuesday of January, March, May, Sept. and Nov.

RICHMOND RAILWAY CLUB. Sec.: F. O. Robinson, 8th & Main Sts., Richmond, Va. Regular meetings on second Thursday of each month, except June, July and August.

ROCKY MOUNTAIN RAILWAY CLUB. Sec.: M. M. Currier, Colorado City. Regular meetings on second Tuesday of each month, at Union Depot, Denver.

ST. LOUIS RAILWAY CLUB. Sec.: E. A. Chenery, Union Station, St. Louis. Regular meetings on second Friday of each month, except July and August.

SOCIETY OF CHEMICAL INDUSTRY, NEW YORK SECTION. Sec.: H. Schweitzer, 40 Stone St. Meetings on third Friday after the first Monday of each month, at Chemists' Club, 108 W. 55th St.

SOUTHERN AND SOUTHWESTERN RAILWAY CLUB. Sec.: W. A. Love, Atlanta, Ga. Regular meetings on third Thursday of Jan., April, Aug. and Nov., at Atlanta.

TECHNICAL SOCIETY OF THE PACIFIC COAST. Sec.: Otto von Geldern, 31 Post St., San Francisco. Regular meetings on first Friday of each month.

TEXAS RAILWAY CLUB. Sec.: T. H. Osborne, Pine Bluff, Ark. Regular meetings on third Monday of April and September.

WESTERN RAILWAY CLUB. Sec.: Jos. W. Taylor, 667 Rookery, Chicago. Meetings on third Tuesday of each month, except June, July and August, Auditorium Hotel, Chicago.

WESTERN SOCIETY OF ENGINEERS. Sec.: J. H. Warder, Monadnock Block, Chicago. Regular meetings on first Wednesday and extra meetings on third Wednesday of each month, except July and August.

Personal.

—Mr. William A. Sweet, the well-known steel maker and manufacturer, died at his home in Syracuse, N. Y., on January 30th.

—Mr. Nikola Tesla announces that in connection with the commercial introduction of his inventions, he will render professional services in the general capacity of consulting electrician and engineer. His laboratory is on Long Island, and his residence at the Waldorf-Astoria Hotel, New York.

—Mr. Putnam A. Bates, assistant secretary and sales manager of the Crocker-Wheeler Company, has resigned that position, and has formed a partnership with Mr. John Neilson, who was until recently assistant secretary and assistant treasurer of the New York & Stamford Electric Railway, and under the firm name of Bates & Neilson, will conduct a general practice of consulting electrical engineering, with offices in New York.

—Mr. George W. Fowler, who for several years has been connected with the engineering department of the C & C Electric Company, has resigned his position with that company and will hereafter be associated with Mr. George D. Beinert, the well-known electrical contractor, 32 Bible House, New York.

—Mr. T. H. Bailey Whipple has returned to the Sawyer-Man Electric Company to the position which he left last summer in order to take part in the reorganization of the Sales Department of the Nernst Lamp Company, of Pittsburg.

—Mr. Herman Johnson, has associated himself with the Acorn Engineering & Manufacturing Company, 27 Thames St., New York, in charge of shop operations.

—Dr. Joseph Hyde Pratt, of the Engineering Co. of America, is examining properties in North Carolina and South Carolina, investigating the tin and monazite deposits in those States.

—Mr. Albert E. Doe, Jr., formerly connected with The Norcross Bros. Co., of Boston, has severed his connection with that firm to take the position of New England salesman for the Thos. H. Dallett Co., of Philadelphia, manufacturers of stone working tools, portable drills, pneumatic hammers and other apparatus.

—Mr. W. S. Chase, sales manager for The National-Acme Manufacturing Company, has gone to England and the Continent on a business trip.

—Mr. W. P. Colton, advertising agent of the Delaware, Lackawanna & Western Railroad Co., will have his duties extended to include the Industrial Department, vice Mr. C. W. Ten Broeck promoted, with title of Industrial and Advertising Agent.

—Mr. John Leonard Kebler, vice-president and general manager of the Ward-Leonard Electric Company, died very suddenly on February 2nd, 1904, at Albuquerque, New Mexico.

Industrial Notes.

—The Silicate Stone Company, of 39 Wall St., New York, have acquired the American rights to Ford's silicate-of-lime stone process, which embodies a simple and cheap method of making artificial building stone in blocks of all sizes, stone brick, tiles and paving slabs. In consequence of the high cost of good natural building stone and the difficulty of obtaining any at all in many localities, attempts have been made, from time to time, to produce a good silicate-of-lime building stone, but Mr. L. P. Ford, of England, is the first who has succeeded in making it commercially in large blocks without cracks. His experiments extended over several years and cost a large sum of money, but he has been finally successful in producing an artificial stone of the highest quality in an economical manner. In the manufacture of this stone, the lime and the sand, at the high temperature and pressure employed, react upon each other, forming a cementitious silicate of lime, to the presence of which the great mechanical strength of the stone is largely due. The resistance of this stone to frost, corrosive atmospheres and sea water is high, and in many cases superior to that of natural stone. Its porosity is small, and it is very durable. On account of its uniform texture and strength, it can be worked and carved very easily, and its hardness can be varied to suit the purposes for which it is intended. Owing to its homogeneous structure, there is also no loss from irregularities and defects, as with natural stone. In appearance, the silicate-of-lime stone is like a fine or coarse-grained sand stone, and is of light or dark cream color, according to the sand used. By the addition of suitable coloring matters it can also be made in several other colors. This stone is manufactured in large or small blocks, to suit the convenience of the builder and the mason, who can work it as they please, and it is also made in the form of bricks, tiles and paving slabs. Arrangements for its manufacture in this country on a large scale are being made, and the Silicate Stone Company, of 39 Wall St., New York, will be glad to furnish full information to all who are interested in this new building material.

—The Allis-Chalmers Co., of Chicago, have widened their scope of manufacture and have engaged in the following new lines of work: Steam turbines; hydraulic machinery; gas engines; electrical machinery. As regards steam turbines, they have become associated with, and form part of, the Steam Turbine Advisory Syndicate, of England, which is composed of the Yarrow

Shipbuilding Co., the Tweedie (Vulcan) Shipbuilding Co., Willans & Robinson, and the Allis-Chalmers Company. Mr. Fullager, formerly chief engineer Parsons Steam Turbine Co., of England, is now consulting engineer for the Steam Turbine Advisory Syndicate. The steam turbines are of the horizontal type, and the Allis-Chalmers Co. are prepared to build sizes of from 500 to 5,000 kilowatts, and can, if required, build up to units of 10,000 kilowatts. Their license from the Advisory Turbine Syndicate concedes to them all of the United States, Canada and Mexico, with equal rights and privileges in South America, and rights to do business elsewhere in the Western Hemisphere. They have concluded arrangements with Escher-Wyss & Co., of Zürich, Switzerland, whereby they become the sole licensees for the Western Hemisphere, for the famous hydraulic machinery of this Swiss firm, some of whose apparatus has been installed at the Niagara Falls plant of the Cataract Construction Co., and whose turbine water wheels enjoy a world-wide reputation. The Allis-Chalmers Co. have bought the Western patents, and have become sole licensees, for the Western Hemisphere, of the Nürnberg Machine Co., Nuremberg, Germany, for the latter's gas engines, and are now prepared to make these engines up to any required horse power, suitable for use with blast-furnace gas or other kinds of gas. The Allis-Chalmers Co. have also entered into the manufacture of generators, motors, and electrical apparatus in all its branches, both for stationary and railroad work, power house installation for transportation purposes and electric lighting. They have engaged to take charge of this department of their business Mr. John F. Kelly, formerly of the Stanley Electric Co., Mr. William Stanley, of the same company, as consulting engineer, and Mr. John H. Kelman, formerly superintendent of the Stanley Company, as superintendent. These new branches of industry, combined with their celebrated reciprocating engines and other older lines of work, will enable the Allis-Chalmers Co. to take contracts for complete power plants of all descriptions and to furnish the best of their respective kinds.

—The Quincy Engine Works, of Quincy, Ill., are builders of special machinery as well as builders of the Williams vertical engines, the Quincy Corliss engines and the Quincy four-plunger motor-driven pumps. They have just completed a set of ten special filter presses for a large glucose factory, together with a motor-driven four-plunger hydraulic pump and hydraulic accumulator for operating them.

—The Acorn Electric & Manufacturing Company, of 27 Thames Street, New York, has changed its name to the Acorn Engineering & Manufacturing Company. This company is equipping a shop for all kinds of experimental and model work and general repairing, with Mr. Herman Jonson in charge of the shop operations.

—P. & F. Corbin, the New Britain, Conn., manufacturers of hardware, have issued a handsome book in commemoration of the semi-centennial of the incorporation of their company. This volume gives a history of the growth of a large organization from small beginnings, with interesting accounts of the men who have built up the business. There are many excellent portraits, views of the works, and other illustrations, all executed in artistic style, the printing and the paper are very good, the binding well made and tasteful, and the whole book forms a worthy memorial of an event which is of general interest on account of the high and wide reputation of the house of P. & F. Corbin, and is particularly remarkable in that the man who organized the company is its active head to-day.

—The American Electric Improvement Co., of Philadelphia, have recently installed their Clark electric water purifying plants at Gila Bend, Arizona, for the Southern Pacific Co., at Philadelphia, for the Puro Electro Water Co., and in Europe, and have also received orders from some manufacturing establishments. They guarantee that their apparatus will purify 360 gallons of Schuylkill River water at a cost of one cent.

—The Iron and Steel Institute will hold its annual general meeting at the Institution of Civil Engineers, in London, on May 5th and 6th, under the presidency of Mr. Andrew Carnegie, at which time the awards for the Carnegie Research Scholarships will be announced. The autumn meeting will take place in New York, on October 24th, 25th and 26th, after which there will

be excursions to the St. Louis Exposition, Niagara Falls and some of the principal American cities. A committee has been formed in the United States for the reception of the Institute, with Mr. Charles Kirchhoff as president, and Mr. Theodore Dwight, of 99 John St., New York, as secretary.

—The Wellman-Seaver-Morgan Company, of Cleveland, Ohio, announce the opening of a Pittsburg office, located at 515 Frick Building, in charge of Mr. Willard N. Sawyer, Manager, for the convenience of the trade adjacent to Pittsburg. Mr. Sawyer has been with the company for a number of years, prior to which he was general superintendent of the Tennessee Coal, Iron & Railroad Company's Steel Works at Ensley, Alabama.

—The Bradley Manufacturing Company, of Pittsburg, have ready, for immediate shipment, one 160-horse-power, 3-line, compound Willans vertical central-valve engine, direct connected to a 100-kilowatt, 125-volt, direct-current, Western Electric Co. generator, both mounted on one base. This engine can be arranged for steam pressure ranging from 100 to 150 pounds, and for condensing or non-condensing.

—The Sprague Electric Company announces that its Baltimore office, which was destroyed in the recent fire, is now located in the Maryland National Bank Building.

—The General Electric Company has established a drafting room apprenticeship course, to which young men who are able to pass a satisfactory examination in arithmetic are eligible. The course is intended to fit applicants for drafting room positions. Further information can be obtained by application to Mr. J. W. Upp, Engineer in charge of Drafting Room, General Electric Company, Schenectady, N. Y.

—The Aultman & Taylor Machinery Co., of Mansfield, O., have secured through the Cahall Sales Department, W. W. Darley, general western agent, the largest instalment of boilers for the Louisiana Purchase Exposition at St. Louis. The instalment will consist of eight 508-H. P. and eight 400-H. P Cahall horizontal water-tube boilers, all equipped with the Mansfield chain grate stokers. The entire sixteen boilers will be equipped with induced draft, furnished by the Buffalo Forge Co.

—The Wm. H. Wilkinson Co., have moved into their new shops at West Medway, Mass., to which place all communications intended for them should be addressed. Their Boston representative is The Wm. H. Gallison Co., 36 Oliver St.

—Mason G. Worth & Co., have removed their offices to 1209 and 1210 Real Estate Trust Building, Philadelphia.

—The Rochester Gas Engine Company announces that it has re-organized, with J. S. Graham, President; J. J. Leary, Vice-President, and W. J. Graham, Secretary and Treasurer. Messrs. J. S. and W. J. Graham have been manufacturers of machinery in the city of Rochester for many years, under the name of The Graham Machine Company, and have recently disposed of their interests to the A. T. Hagen Company.

—W. H. Coverdale & Company have recently been incorporated to do a general engineering and contracting business, with offices at 66 Broadway, New York.

—Even the appalling fire which recently swept a large part of Baltimore out of existence will benefit some. The salvage companies, who salvage goods damaged by fire and sell them for the benefit of the fire insurance companies, will profit by this loss. The goods damaged must be carefully dried before they become saleable, much depending upon the success of this drying. The Underwriters' Salvage Co., of New York City, recently placed an order with the B. F. Sturtevant Co., of Boston, for the complete equipment of a kiln for drying such goods by the Sturtevant fan system. The kiln is not only equipped with the Sturtevant apparatus for drying, consisting of a Sturtevant steam fan connected to a Sturtevant fireproof heater and galvanized iron distributing pipes, but the entire material and workmanship for making the rooms fireproof was furnished by the B. F. Sturtevant Co.

—The Roessler & Hasslacher Chemical Co., of 100 William St., New York, have issued a calendar, with an attractive picture in a tasteful frame.

—The Poole Engineering & Machine Company announce that their works at Woodberry were not injured by the recent destructive fire in Baltimore, but that their office on German St., was entirely destroyed, after the books and papers were removed

in safety. They have concluded, therefore, to combine their entire office force at Woodberry, where they are just completing a fireproof office building, which will afford them ample accommodation.

—The American Water Softener Company, of Philadelphia, have opened a branch office in the Outlook Building, Columbus, O., which is in charge of Mr. W. H. P. Fisher, general sales agent for the company, and Mr. A. C. Tomlinson, manager of the Columbus office, who for some time was assistant manager of the Philadelphia office.

—The Bullock Electric Manufacturing Company, of Cincinnati, have established temporary quarters for their Baltimore district manager at 303 Cortlandt St., as the regular offices were destroyed in the fire.

—The Nernst Lamp Company, in accordance with its new policy of establishing district offices in the large cities, has recently opened an office at 47 State Street, Detroit, Mich., and appointed Mr. Charles F. Case as district sales manager there. The territory embraced by this office is the lower peninsula of the State of Michigan, the northwestern part of Ohio and the northeastern part of Indiana.

—The Weber Gas and Gasoline Engine Company, of Kansas City, Mo., will exhibit one of their vertical two-cylinder engines, of 150-horse power, at the St. Louis World's Fair. Besides this, their exhibit will include a Weber gas producer, and an electric generator to be driven by the engine.

—The Power and Mining Machinery Company, of New York, which manufacture and sell Loomis-Pettibone gas apparatus, Holthoff mining machinery and American Crossley gas engines, have recently made a contract with the Elmira Water, Light and Railroad Co., of Elmira, N. Y., for a 1300-horse-power Crossley gas engine, to operate with natural gas and to be direct-connected to a General Electric alternator.

—The Standard Tool Company, of Cleveland, the manufacturers of twist drills and other specialties, have issued a calendar containing useful and practical mechanical information.

—A large order for Pelton water wheels is being completed for the Columbia Improvement Company, near Tacoma, Wash. The installation consists of four Pelton units, aggregating 31,000 horse-power, operating under an 850-foot head. These are the largest water-wheel units in the world, with the exception of those at Niagara Falls and demonstrate the facilities of the Pelton Co. for handling especially large orders. An 88-page illustrated catalogue, containing complete data in reference to hydraulic power, can be obtained by addressing the Pelton Water Wheel Co., 111 Main St., San Francisco, and 148 Liberty St., New York.

—The Jeffrey Manufacturing Company, of Columbus, Ohio, through their connection with the Ohio Malleable Iron Company, of the same place, are now in the field soliciting orders for high grade malleable castings.

—The American School of Correspondence, at the Armour Institute of Technology, Chicago, publishes a "Cyclopedia of Engineering," which contains the essence of the engineering subjects taught by the School. The cyclopedia is in four volumes, and is made up of condensed, practical information, useful in every-day work, and is intended to furnish actual instruction to those who cannot take a correspondence course.

—The Tengwall File and Ledger Company, of Chicago, publish a bright little monthly magazine, devoted to modern business methods, called *Tengwall Talk*. Among the novel and convenient devices brought out by this company is a perpetual vest-pocket memorandum book, 2 by 4 inches, bound in black flexible leather and fitted with fifty bond paper sheets, which can be replaced when used.

—The Pittsburg Shear Knife and Machine Company, has changed its name to the Heppenstall Forge & Knife Company, while remaining under the same management.

—*The Electric Club Journal*, which is published monthly by The Electric Club, of Pittsburg, made its first appearance in February, and if it maintains the standard set by its initial number, it will prove an interesting and valuable addition to technical journalism. *The Electric Club Journal* is written for the young engineer, and while it is primarily the organ of The Electric Club, and the mouthpiece of the engineering apprentices in the various Westinghouse establishments, it possesses a general interest which will appeal to a far wider constituency.

NEW CATALOGUES AND TRADE PUBLICATIONS

These catalogues may be had free of charge on application to the firms issuing them. Please mention The Engineering Magazine When you write.

Asbestos.

Booklet devoted to asbestos for theatre curtains, scenery, rope, upholstery, carpeting, walls and other uses, together with samples of asbestos theatre-curtain cloth, with and without interwoven wire. 6 by 3½ in.; pp. 4. H. W. Johns-Manville Co., 100 William street, New York.

Boilers.

Circulars, containing illustrations and descriptions of Mosher water-tube boilers, and tests of these boilers on the U. S. Monitor "Florida." Many torpedo boats and fast yachts have also been equipped with Mosher boilers, including the "Arrow," with a speed of 45 miles an hour; the "Ellide," 40 miles an hour, and others. 5½ by 9 in. Mosher Water-Tube Boiler Co., 1 Broadway, New York.

Bolt Machinery.

Catalogue D, containing illustrations and descriptions of Burdict bolt machinery, comprising square headers, hexagon headers, nut-burring machines, hot-pressed-nut machines, automatic threaders, pointers, nutters and tappers, and also of Schlenker bolt cutters. 9 by 6 in.; pp. 36. Howard Iron Works, Buffalo.

Concrete Mixers.

Circular with illustrations and descriptions of the Stanley Prismatic Drum concrete mixer for batch mixing, adapted for driving by steam, gasoline or electricity, and the Portable Gravity concrete mixer, for continuous mixing, with useful tables and information about concrete, cement and cement testing, mortar and artificial stone. 6 by 7 in.; pp. 8. Contractors' Plant Company, Boston.

Conduit.

Pamphlet, containing handsome illustrations and descriptions of bituminized fiber conduit for underground electrical work and various applications of this conduit, which is electrolysis proof and non-corrosive, moisture proof and non-abrasive. 7½ by 6½ in.; pp. 32. American Conduit Co., Los Angeles, Cal.

Counting Machines.

Circular, with return postal card, devoted to Durant counting machines, which are especially adapted to printing presses. 5½ by 3½ in.; pp. 8. W. N. Durant, 235 22d Street, Milwaukee.

Cranes.

Catalogue No. 15, with handsome half-tone illustrations and descriptions of large electric traveling cranes for steel works, machine shops and other establishments, as they appear in operation, and of their parts, with specifications and partial list of users. 9 by 12 in.; pp. 56. Also, catalogue No. 14, devoted to hand-power cranes of various types. 9 by 12 in.; pp. 15. The Case Manufacturing Co., Columbus O.

Electric Driving.

Bulletin No. 40, with illustrations and descriptions of electric motors for cranes and hoists of various kinds. 10 by 7½ in.; pp. 16. Also a number of flyers, with illustrated descriptions of various kinds of machine tools equipped with electric motors, and an account of a method of multiple-voltage, variable-speed control. 7 by 4½ in. Crocker-Wheeler Company, Ampere, N. J.

Electric Vehicles.

Circular No. 1059, containing descriptions and illustrations of electric motors, controllers, storage-battery indicators, and other parts of electric-vehicle motive-power equipments. 10 by 7 in.; pp. 24. Also circular No. 1032, devoted to electric railway motors; circular No. 1061, describing automobile charging outfits, and folder No. 4006, devoted to auxiliary apparatus for railway equipments. Westinghouse Electric & Manufacturing Co., Pittsburg.

Elevator.

Circular, illustrating and describing the Mabbs counterbalance electric elevator, in which the electric motor travels up and down vertical racks and counterbalances the car and its average load. 8½ by 3¼ in.; pp. 8. Mabbs Electric Elevator Co., Chicago.

Fireproof Construction.

Illustrated and descriptive catalogue of fireproof building material, including "Phœnix" hollow wall construction, red clay and glass roofing tiles and the "Herculean" terra cotta flat arch, with views of buildings employing these methods of construction and records of test. 9 by 6 in.; pp. 20. Henry Maurer & Son, 420 East 23d Street, New York.

Gasoline Engines.

Booklets and circulars devoted to gas, gasoline, distillate crude oil and kerosene engines for all purposes, and to dynamos and electric motors. Fairbanks, Morse & Co., Chicago.

Grab Buckets.

Circular No. 77, with illustrations and descriptions of grab buckets, made in three pieces, with very wide opening, which are absolutely self-filling, and will work in ore, mine-run coal, broken limestone, gravel and sand, and will also excavate in clay, gravel and soft earth of any nature. 3½ by 6 in.; pp. 12. The Jeffrey Manufacturing Co., Columbus, O.

Grate Bars.

Booklet describing and illustrating the Hall patent grate bar for steam boiler furnaces, kilns and other places, and giving a list of users of these grate bars. Also, an illustrated description of Stowell's compound-lever car mover. 6 by 3½ in.; pp. 16. Stowell Mfg. & Fdry. Co., South Milwaukee, Wis.

Industrial Railways.

Catalogue 038, containing illustrations and descriptions of narrow-gauge railways for manufacturing establishments, special tracks, a great variety of cars, electric locomotives and all other accessories, with views showing these railways in operation, and memoranda for engineers and architects. 9 by 6½ in.; pp. 52. C. W. Hunt Company, West New Brighton, Staten Island, N. Y.

Loose-Leaf Devices.

Catalogue of Tengwall "time savers," including loose-leaf files, ledgers, price books, scrap books, music books, binders, perforators and other loose-leaf devices. 9 by 6 in.; pp. 52. Tengwall File & Ledger Co., Chicago.

Machine Tools.

Catalogue, with illustrations and descriptions of tapping machines, riveting machines, screw slotters, speed indicators, round-belt cutter and punch, brass machine screws, and other machinery and tools. 7 by 5½ in.; pp. 31. Also catalogue No. 7, devoted to incandescent electric-lamp pull sockets and pull clusters and other high-grade electric specialties. 3½ by 6½ in.; pp. 59. Harvey Hubbell, Bridgeport, Conn.

Booklet, with illustrations and descriptions of modern high-standard lathes, planers, shapers, upright drills, radial drills and boring mills for rapid work production. 3½ by 6 in.; pp. 15. The American Tool Works Co., Cincinnati.

Overhead Tramway.

Catalogue No. 60, containing illustrations and descriptions of the Coburn patent carrying system or overhead tramway, and other styles of overhead trolleys for manufacturing plants, repair shops, packing and cold-storage houses and other establishments, regular and special forms of cranes and other kinds of conveying, unloading and hoisting machinery. 9 by 6 in.; pp. 32. New Jersey Foundry & Machine Co., 9-15 Murray Street, New York.

Piling.

Pamphlet, with illustrations and descriptions of interlocking channel-bar steel piling for cofferdams, bridge foundations, water-tight bulkheads, dry docks, dams, mine shafts, building foundations and deep excavations of all kinds, and views showing engineering works where this steel piling was used. 9 by 6 in.; pp. 40. Friestedt Interlocking Channel Bar Company, Chicago.

Pipe Machines.

Circular, with illustrations and descriptions of the Standard Wieland 6-inch pipe-threading and cutting machine, with adjustable expanding chasers for 1¼-inch to 6-inch pipe. 6 by 9 in.; pp. 4. Standard Engineering Co., Ellwood City, Pa.

Power Equipment

Bulletin, Series C, No. 3, containing a well-illustrated article, abstracted from *Power*, giving a description of the steam and electric power installation in the Mexican Central Railway Company's new shops at Aguascalientas. 10 by 7 in.; pp. 12. D'Olier Engineering Company, Philadelphia.

Punches and Shears.

Catalogue, with illustrations and descriptions of punches and shears in various styles, for belt and hand power, bending rolls and woodworking machinery. 7 by 5 in.; pp. 31. Badger State Machine Co., Janesville, Wis.

Quartz Mill.

Catalogue No. 6, third edition, illustrating and describing the Huntington centrifugal roller quartz mill, for pulverizing gold ores, and other ore milling and concentrating machinery. 9 by 6 in.; pp. 18. Harron, Rickard & McCone, San Francisco.

Steam Engines.

Bulletin No. 8A, with illustrations and descriptions of Haberkorn automatic cut-off steam engines, and their parts, particularly the cylinder valve chambers and piston valves. 11 by 7½ in.; pp. 4. Haberkorn Engine Co., Fort Wayne, Ind.

Steam-Engine Test.

Booklet, the second number of the "Engineering Lore Series," containing an illustrated comprehensive description of a test of a horizontal tandem compound high-speed steam engine, made at Sibley College, Cornell University, by Prof. R. C. Carpenter. Buffalo Forge Company, Buffalo.

Watchman Clocks.

Pamphlet illustrating and describing the Howard electric clock and system for making a record of watchman's rounds, which is permanent and cannot be tampered with. The clocks may be also fitted with a program attachment. There is a long list of users of these clocks. 8 by 4 in.; pp. 32. The E. Howard Clock Co., Boston.

Water-Wheel Governors.

Circular, with illustrations of Sturgess water-wheel governors, and letters of recommendation. 9 by 6 in.; pp. 12. The Turbine Engineering Company, West Troy, N. Y.

Wire Cloth.

Price list of catalogue No. 21, giving information about Tyler double-crimped iron or steel wire cloth, brass or copper wire cloth, phosphor bronze wire cloth, heavy wire screen, and other kinds of wire cloth and screen. 6 by 3½ in.; pp. 63. The W. S. Tyler Company, Cleveland.

Wire-Rope Tramways.

Catalogue, containing comprehensive descriptions of wire-rope aerial tramways, with illustrations of a seventeenth century rope tramway, a piece of wire rope unearthed at Pompeii, and many modern installations of aerial tramways and other applications of wire rope. 7 by 9¼ in.; pp. 50. Broderick & Bascom Rope Co., St. Louis, Mo.

Wrenches.

Booklet, with illustrations, description and prices of Keystone crocodile or alligator wrenches made of high-grade steel, properly and uniformly tempered. 5 by 3½ in.; pp. 4. Keystone Drop Forge Works, Chester, Pa.

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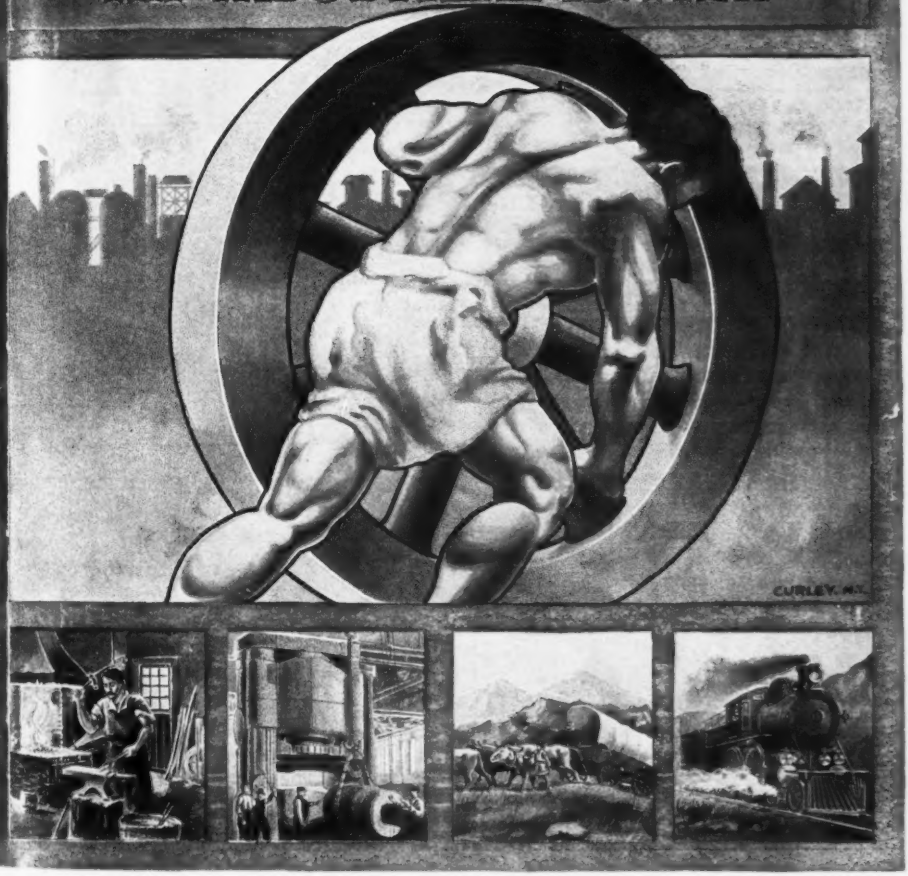

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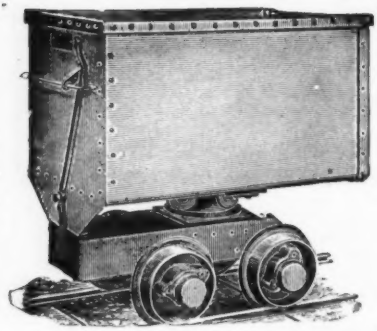

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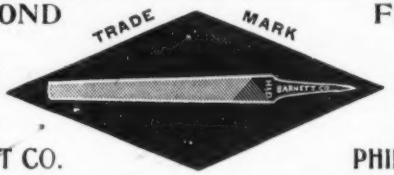

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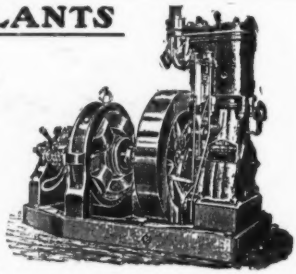

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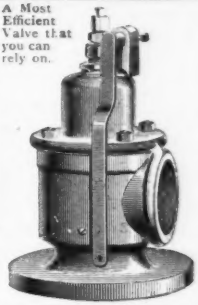

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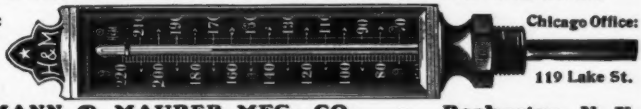

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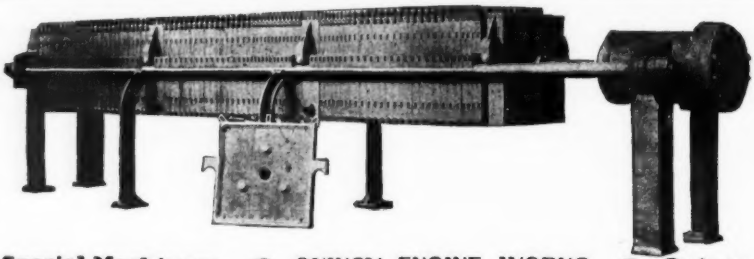

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THE ENGINEERING MAGAZINE

CONTENTS, MARCH, 1904

THE WORLD'S GREAT LABOR SAVERS AND LABOR SERVERS—
Inventions That Have Made Employment for Millions — ROBERT W. HUNT — 803

THE RISE OF LABOR THROUGH LABOR-SAVING MACHINERY—
Advances in Capacity, Skill, Wages and Social Status — FRANK H. ROSE — 836

THE PRIME MOVER AND ITS INFLUENCE ON THE WORLD'S PROGRESS—
Water Power and Steam as Agencies to Uplift Mankind — JOHN E. SWEET — 846

WHAT THE INVENTOR HAS DONE FOR THE RAILWAY WORKER—
Labor-Saving Devices the Basis of the Railway's Growth — A. M. WAITT — 872

HYDRAULIC POWER APPLIANCES IN THE ENGINEERING INDUSTRIES—
Their Great Economy and Efficiency in Special Services — GEORGE H. BAXTER — 878

LABOR-SAVING MACHINERY IN FOUNDRY OPERATIONS—
Modern Practice, and the Gain to Employer and Employee — RICHARD MOLDENKE — 896

THE DEVELOPMENT OF POWER-DRIVEN MACHINERY IN THE MINE—
Appliances that Make a Vast Mineral Industry Possible — E. H. ROBERTON — 925

MECHANICAL AUXILIARIES TO THE ECONOMY OF THE FIRE ROOM—
Skilled Intelligence Replacing the Toil of the Stoker — R. P. BOLTON — 950

THE RELATION OF ELECTRICAL INVENTIONS TO HUMAN ACTIVITY—
How they Lighten Work, Enlarge Output, and Give Employment — LOUIS BELL — 967

REVIEW OF THE ENGINEERING PRESS

The Production of Radium by Extraction from the Ore—981
Influence of Engineering Education—Science and the Universities—983
Recent Experimental Determinations of the Specific Heat of Steam—985
Multiple-Propulsion Trains for Mechanical Road Traction—986
Latest Developments of the Single-Phase Electric Motor for Railways—988
Report of the Alloys Research Committee on the Heat-Treatment of Steel—991
Electrical Statistics in Germany—Development of Generating Stations—993
Gas Engines in Railroad Work for Pumping, Inspection, Motive Power—994
Railway Construction in Switzerland—The Engadine Lines—996
Abuses and Possible Remedies in Patent-Law Administration—997
Technical Education in Germany—British and German Methods—999
The Nature of Invention—Development of Scientific Methods—1001
Modifications in Design of Machine Tools for High-Speed Steel—1002
The Maintenance of Open Harbors by Modern Ice Breakers—1003

THE ENGINEERING INDEX

With Descriptive Notes Clearly Indicating the Character and Purpose of Current Leading Articles in the Technical Press of the World.

CIVIL ENGINEERING 1005
ELECTRICAL ENGINEERING . . 1010
GAS-WORKS ENGINEERING . . . 1017
INDUSTRIAL ECONOMY 1017
MARINE AND NAVAL ENGINEERING . 1019
MECHANICAL ENGINEERING . . 1020
MINING AND METALLURGY . . . 1027
RAILWAY ENGINEERING . . . 1032
STREET AND ELECTRIC RAILWAYS, 1034

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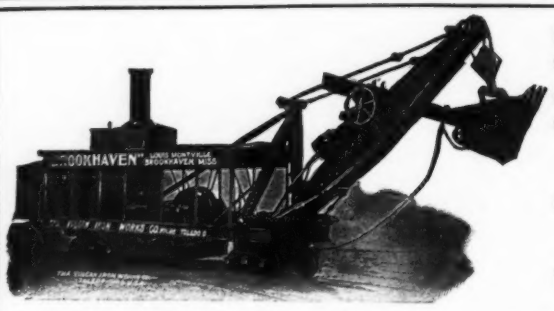

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AUTHORS AND PAPERS FOR MARCH, 1904.

ROBERT W. HUNT *(The World's Great Labor Savers and Labor Servers)*—Born 1838; educated Covington, Ky.; worked in a Pottsville rolling mill and learned practically the processes of iron manufacture; in 1859-60 studied chemistry and became chemist to the Cambria Iron Co.; entered the army during the U. S. civil war, and rose to rank of captain; in 1865 became superintendent of steel works at Wyandotte, Mich., then returned to the Cambria Co. and was with them until 1873; with John A. Griswold & Co., Troy, 1873-75; with the Troy Steel & Iron Co., 1875-88. Since 1888, head of Robert W. Hunt & Co., consulting engineers, Chicago. Member of the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Iron & Steel Institute, the American Society of Civil Engineers, the American Society of Mechanical Engineers (president 1891), the American Institute of Mining Engineers (president 1883-84), the Western Society of Engineers, etc.

FRANK H. ROSE *(The Effects of Labour-Saving Machinery)*—Born in Lambeth, and educated in a London elementary school, continuing with night school classes for some years after beginning work. Apprenticed to Maudslay, Sons & Field 1872-78; the great trade depression of the ensuing years gave him early experience of the hardships of the wage earner, and influenced his thought upon industrial questions; joined the Lambeth branch of the Amalgamated Society of Engineers in 1878, and until the last three years was almost continually in office in the society; in 1893 was appointed one of the six district organisers and went to live in Liverpool; then received an appointment in Manchester which he held until April, 1903, until his Parliamentary candidature rendered other arrangements necessary. His present connections are journalistic.

JOHN E. SWEET *(The Prime Mover and Its Influence on the World's Progress)*—Born 1832; educated in district schools; farmer's boy, then carpenter's apprentice until 1850; builder and architect in the southern States until 1861; inventor and mechanical draughtsman until 1873; professor practical mechanics, Cornell University, 1873-79; expert and juror, World's Columbian Exposition, 1893, on machine tools; first president Engine Builders' Association of the United States, 1899-1901; founder of the American Society of Mechanical Engineers (president 1883-84).

ARTHUR M. WAITT *(What the Inventor Has Done for the Railway Worker)*—Until 1903 superintendent of motive power and rolling stock of the New York Central & Hudson River Railway; member of the American Society of Mechanical Engineers (vice-president 1900-1902).

GEORGE HANDYSIDE BAXTER *(Hydraulic Power Appliances in the Engineering Industries)*—Mechanical engineer. Educated at High School, Dundee; served apprenticeship with Gourlay Bros. & Co. of that city, and after a short time with John Elder & Co., now the Fairfield Shipbuilding Co., Ltd., as a draughtsman, entered in 1872 the service of the Barrow Shipbuilding Co., now Vickers, Maxim, Ltd., as chief draughtsman in their engine department; in 1881 removed to the firm of Ramage & Ferguson, shipbuilders, Leith, as constructor and manager of their new engine works. From thence in 1889 engaged in a similar capacity with Barclay Aule & Co., Ltd., shipbuilders and engineers, Glasgow, and in 1892 joined the service of the Clyde Navigation Trust as their mechanical engineer and manager of their large repairing works at Dalmuir; member of the Institution of Engineers and Shipbuilders in Scotland since 1881.

AUTHORS AND PAPERS FOR MARCH, 1904.

DR. RICHARD MOLDENKE *(Labor-Saving Machinery in Foundry Operation)*—Born Watertown, Wis., 1864; graduated from Columbia University, 1885, with degree of Ph. D. A specialist in the metallurgy of cast iron and expert in malleable castings, and an extensive writer on the metallurgy of iron and steel. Was for some years in Pittsburg; at present is Secretary of the American Foundrymen's Association. Dr. Moldenke has taken very active interest in the work of the International Association for Testing Materials.

E. H. ROBERTON *(The Development of Power-Driven Machinery in the Mine)*—Born in the West Riding of Yorkshire, 1877, but has lived almost all his life in Northumberland, the centre of the British mining industry; educated at Leatherhead School, gaining an open mathematical scholarship to Christ Church, Oxford; graduated in the Honours School of Mathematics in 1899; studied engineering at Rutherford College, Newcastle-on-Tyne, and worked for more than three years in the mines of the Seaton Delaval Coal Co., Ltd.; in 1892 accepted the post of demonstrator of mining at the University of Birmingham, and has since assisted Professor Redmayne in his work in connection with the studies and investigations of the Royal Coal Commission.

REGINALD PELHAM BOLTON *(Mechanical Auxiliaries to the Economy of the Fire-Room)*—Born and apprenticed in England; served as assistant engineer at the Edgemoor Iron Works and as assistant to Dr. Erasmus Leavitt; has been in practice in New York City since 1895 on the equipment of large buildings, having designed, within the last few years, the equipment of the Bowling Green offices, the Grand Central Station, the Royalton and Lorraine hotels. He originated the vertical system of electric wiring and duplex-pressure hydraulic-elevator system; has been in charge of the remodeling of the Ridgewood Pumping Station for the City of Brooklyn, before and since its incorporation with the city of New York, from 1896 to 1900; associate member of the Institution of Civil Engineers, member of the American Society of Civil Engineers, and of the American Society of Mechanical Engineers.

LOUIS BELL *(The Relation of Electrical Inventions to Human Activity)*—Graduated from Dartmouth College, 1884, and took the degree of Ph. D. at Johns Hopkins University, 1888; professor of Physics and Applied Electricity at Purdue University, Lafayette, Ind., 1888-89; consulting engineer, Chicago (firm of Bliss & Bell), 1889; editor of *The Electrical World*, N. Y., 1890-91; member A. I. E. E., 1890; engineer in charge of power-transmission work of the General Electric Co., 1892-95; at present consulting engineer, Boston, Mass., making a specialty of power transmission and heavy electric-railway work. Dr. Bell's wide range of experience in all fields of electric practice enables him to discuss his topic with matchless authority.

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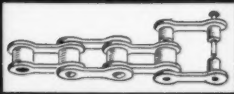

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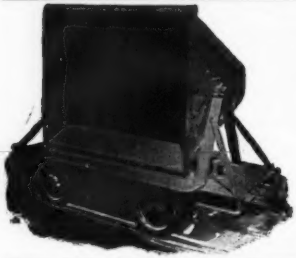

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Hartford S. B. I. & Ins. Co., Hartford, Conn.

Boiler-Makers' Tools.

Hilles & Jones Co., Wilmington, Del.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Philadelphia Pneumatic Tool Co., Philadelphia, Pa.
Pratt & Whitney Co., Hartford, Conn.
Stow Flexible Shaft Co., Philadelphia, Pa.

Boilers.

Allis-Chalmers Co., Chicago, Ill.
American Well Works, Aurora, Ill.
Atlantic Works, East Boston, Mass.
Atlas Engine Co., Indianapolis, Ind.
Aultman Company, Canton, Ohio.
Babcock & Wilcox Co., 85 Liberty St., New York.
Bradley Mfg. Co., Pittsburg, Pa.
Cahall Sales Department, Pittsburg, Pa.
Contractors' Supply & Equipment Co., Chicago, Ill.
Harrison Safety Boiler Works, 3138 N. 17th St., Philadelphia, Pa.
Harron, Rickard & McCone, 21 Fremont St., San Francisco, Cal.
Heine Safety Boiler Co., St. Louis, Mo.
Kingsford Foundry & Machine Co., Oswego, N. Y.
P. B. McCabe & Co., 602 N. Main St., Los Angeles, Cal.
Riter-Conley Mfg. Co., Pittsburg, Pa.
S. Morgan Smith Co., York, Pa.
Stirling Co., Chicago, Ill.
Struthers-Wells Co., Warren, Pa.
Robt. Wetherill & Co., Chester, Pa.
Wickes Bros., Saginaw, Mich.

Boiler Tube Cleaners.

Wm. B. Pierce Co., Buffalo, N. Y.

Bolt and Nut Machinery.

Acme Machinery Co., Cleveland, Ohio.
The National Machinery Co., Tiffin, O.
Niles-Bement-Pond Co., 136 Liberty St., New York.

Books.

Association of Engineering Societies, Phila., Pa.
Henry Carey Baird & Co., 810 Walnut St., Philadelphia, Pa.
Derry-Collard Co., 256-257 Broadway, New York.
Frederick J. Drake & Co., 211 E. Madison St., Chicago, Ill.
Eng'g Magazine Press, 120-122 Liberty St., N. Y.
John Wiley & Sons, 43 E. 19th St., New York.

Boring Bars.

H. B. Underwood & Co., 1025 Hamilton St., Philadelphia, Pa.

Boring Mills.

Bullard Machine Tool Co., Bridgeport, Conn.
Frank Machinery Co., Buffalo, N. Y.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Pond Machine Tool Co., Plainfield, N. J.
Wm Sellers & Co., Inc., Philadelphia, Pa.

Box Makers' Machinery.

J. A. Fay & Egan Co., 212-232 West Front St., Cincinnati, Ohio.

Brass Founders' Supplies.

The S. Obermayer Co., Cincinnati, Ohio.

Brick.

Henry Maurer & Son, 420 E. 23d St., New York.
Pennsylvania Silica Brick Mfg. Co., Pittsburg, Pa.

Brick and Tile Machinery.

American Blower Co., Detroit, Mich.
Jeffrey Mfg. Co., Columbus, Ohio.
Vulcan Iron Works Co., Toledo, Ohio.

Bridge Timbers and Ties.

American Lumber & Mfg. Co., Pittsburg, Pa.

Buckets, Automatic.

Hayward Co., 97 Cedar St., New York.

Bulldozers.

National Machinery Co., Tiffin, Ohio.
Niles-Bement-Pond Co., 136 Liberty St., New York.

Cable-Railway Machinery.

Allis-Chalmers Co., Chicago, Ill.
A. Leschen & Sons Rope Co., St. Louis, Mo.
John A. Mead Mfg. Co., 11 Broadway, New York.
Poole Engineering & Machine Co., Baltimore, Md.

Cables, Electric and Submarine.

General Electric Co., New York.
Sprague Electric Co., 527 W. 34th St., New York.

Cableways—Steam and Electric.

Lambert Hoisting Engine Co., Newark, N. J.
Lidgerwood Mfg. Co., 96 Liberty St., New York.

Cables, Wire.

Broderick & Bascom Rope Co., St. Louis, Mo.
Cooper, Hewitt & Co., 17 Burling Slip, New York.
A. Leschen & Sons Rope Co., St. Louis, Mo.
Lidgerwood Mfg. Co., 96 Liberty St., New York.
Trenton Iron Co., Trenton, N. J.

Calculating Machines.

Calculagraph Co., 9-13 Maiden Lane, New York.
Keuffel & Esser Co., 127 Fulton St., New York.

Carborundum.

Carborundum Co., Niagara Falls, N. Y.

Card Index Systems.

Globe-Wernicke Co., Cincinnati, Ohio.

Cars.

Arthur Koppel, 66-68 Broad St., New York.
Wonham-Magor Eng'g Wks., 29 B'way, New York.
G. L. Stuebner, Long Island City, N. Y.

Car Shop Machinery.

J. A. Fay & Egan Co., 212-232 West Front St., Cincinnati, Ohio.
Hilles & Jones Co., Wilmington, Del.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Pond Machine Tool Co., Plainfield, N. J.
Pratt & Whitney Co., Hartford, Conn.

Carriage and Wagon Machinery.

American Blower Co., Detroit, Mich.
J. A. Fay & Egan Co., 212-232 West Front St., Cincinnati, Ohio.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.

Castings, Iron, Steel and Brass.

E. R. Allen Foundry Co., Corning, N. Y.
Allis-Chalmers Co., Chicago, Ill.
Aultman Company, Canton, Ohio.
Buffalo Foundry Co., Buffalo, N. Y.
Buhl Malleable Co., Detroit, Mich.
Christensen Engineering Co., Milwaukee, Wis.
Diamond Drill & Machine Co., Birdsboro, Pa.
Stanley G. Flagg & Co., Philadelphia, Pa.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City.
Jeffrey Mfg. Co., Columbus, Ohio.
Maryland Steel Co., Sparrows Point, Md.
Pennsylvania Steel Co., Steelton, Pa.
Poole Engineering & Machine Co., Baltimore, Md.

For Alphabetical Index to Advertisers see inside back cover.

Quincy Engine Works, Quincy, Ill.
Paul S. Reeves & Son, Philadelphia, Pa.
E. M. Shaw, Providence, R. I.
John Simmons Co., 110 Centre St., New York.
Southwark Foundry & Machine Co., Phila., Pa.
Walworth Manufacturing Co., Boston, Mass.
Robt. Wetherill & Co., Chester, Pa.

Cast-Iron Pipe.

McNab & Harlin Mfg. Co., 56-60 John St., N. Y.
Pittsburg Valve, Fdy. & Cons. Co., Pittsburg, Pa.
John Simmons Co., 110 Centre St., New York.
U. S. Cast Iron Pipe & Fdy. Co., Philadelphia, Pa.
Walworth Manufacturing Co., Boston, Mass.
R. D. Wood & Co., Philadelphia, Pa.

Catalogue Covers.

Tengwall File & Ledger Co., Chicago, Ill.

Cement Machinery.

Allis-Chalmers Co., Chicago, Ill.
Bethlehem Fdy. & Mch. Co., South Bethlehem, Pa.
H. W. Caldwell & Sons Co., Chicago, Ill.
Dodge Mfg. Co., Mishawaka, Ind.
W. D. Dunning, Syracuse, N. Y.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
F. L. Smidth & Co., 66 Maiden Lane, New York.
E. H. Stroud & Co., Chicago, Ill.
Vulcan Iron Works Co., Toledo, Ohio.

Cement—Portland.

American Cement Co., Philadelphia, Pa.
Atlas Portland Cement Co., 30 Broad St., N. Y.
Edison Portland Cement Co., Philadelphia, Pa.
Kelley Island Lime & Transport Co., Cleveland, O.
Lawrence Cement Co., 1 Broadway, New York.

Chains.

Buhl Malleable Co., Detroit, Mich.
Morse Chain Co., Trumansburg, N. Y.

Chain Belting.

Aultman Company, Canton, Ohio.
H. W. Caldwell & Sons Co., Chicago, Ill.
Case Mfg. Co., Columbus, Ohio.
Jeffrey Manufacturing Co., Columbus, Ohio.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.

Chain Joint.

Morse Chain Co., Trumansburg, N. Y.

Chain Making Machinery (Welded Chain).

Turner, Vaughn & Taylor Co., Cuyahoga Falls, O.

Chemicals.

F. W. Braun & Co., Los Angeles, Cal.
Roessler & Hasslacher Chem. Co., 100 William St., New York.

Chemical Works Machinery.

Atlantic Works, East Boston, Mass.

Chemists.

Chas. Catlett, Staunton, Va.
L. B. Darling, 79 Sabin St., Providence, R. I.
Robt. W. Hunt & Co., Chicago, Ill.

Chucks

American Tool & Machine Co., Boston, Mass.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Standard Tool Co., Cleveland, Ohio.

Circuit Breakers.

The Cutter Co., Philadelphia, Pa.

Clay-Working Machinery.

American Blower Co., Detroit, Mich.
Aultman Company, Canton, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
E. H. Stroud & Co., Chicago, Ill.
Turner, Vaughn & Taylor Co., Cuyahoga Falls, O.
Vulcan Iron Works, Toledo, Ohio.

Clocks—Time Recording.

E. Imhauser & Co., 206 Broadway, New York.

Clutch Pulleys.

H. W. Caldwell & Sons Co., Chicago, Ill.
Case Mfg. Co., Columbus, Ohio.
Dodge Mfg. Co., Mishawaka, Ind.

Coal and Ashes-Handling Machinery.

Aultman Company, Canton, Ohio.
Broderick & Bascom Rope Co., St. Louis, Mo.
H. W. Caldwell & Sons Co., Chicago, Ill.
The Hayward Co., 97 Cedar St., New York.
C. W. Hunt Co., West New Brighton, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Arthur Koppel, 66 Broad St., New York.
A. Leschen & sons Rope Co., St. Louis, Mo.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
John A. Mead Mfg. Co., 11 Broadway, New York.
Robins Conveying Belt Co., 14-22 Park Row, N. Y.

Coal-Mining Machinery.

Allis-Chalmers Co., Chicago, Ill.
Broderick & Bascom Rope Co., St. Louis, Mo.
Geo. F. Blake Mfg. Co., 114 Liberty St., New York.
General Electric Co., New York.
C. W. Hunt Co., West New Brighton, New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Jeffrey Manufacturing Co., Columbus, Ohio.
Knowles Steam Pump Wks., 114 Liberty St., N. Y.
Arthur Koppel, 66 Broad St., New York.
Laidlaw-Dunn-Gordon Co., 116 Liberty St., N. Y.
Lambert Hoisting Engine Co., Newark, N. J.
A. Leschen & Sons Rope Co., St. Louis, Mo.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
John H. McGowan Co., Cincinnati, Ohio.
Norwalk Iron Works, South Norwalk, Conn.
Rand Drill Co., 128 Broadway, New York.
Robins Conveying Belt Co., 14-22 Park Row, N. Y.
Triumph Electric Co., Cincinnati, Ohio.
Vulcan Iron Works Co., Toledo, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Coal Screens.

Allis-Chalmers Co., Chicago, Ill.
Hendrick Mfg. Co., Ltd., Carbondale, Pa.
Jeffrey Manufacturing Co., Columbus, Ohio.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
John A. Mead Mfg. Co., 11 Broadway, New York.

Concentrators.

P. B. McCabe & Co., 602 No. Main St., Los Angeles, Cal.
Harron, Rickard & McCone, San Francisco, Cal.

Concrete Mixers.

Contractors' Supply & Equipment Co., Chicago, Ill.
W. D. Dunning, Syracuse, N. Y.
Ransome Concrete Mchy. Co., 11 B'way, N. Y. C.

Condensers.

Alberger Condenser Co., 95 Liberty St., New York.
Allis-Chalmers Co., Chicago, Ill.
Geo. F. Blake Mfg. Co., 114 Liberty St., New York.
Deane Steam Pump Co. of Holyoke, 116 Liberty St., New York.
Guild & Garrison, Brooklyn, N. Y.
Knowles Steam Pump Wks., 114 Liberty St., N. Y.
Laidlaw-Dunn-Gordon Co., 116 Liberty St., N. Y.
John H. McGowan Co., Cincinnati, Ohio.
Snow Steam Pump Works, 116 Liberty St., N. Y.
Southwark Foundry & Machine Co., Phila., Pa.
Struthers-Wells Co., Warren, Pa.
Wheeler Condenser & Engineering Co., 120 Liberty St., New York.
Henry R. Worthington, 118 Liberty St., New York

Conduits.

American Conduit Co., 336 Macy St., Los Angeles, Cal.

Construction Timbers (Yellow Pine).

American Lumber & Mfg. Co., Pittsburg, Pa.

Controllers.

The Cutler-Hammer Mfg. Co., Milwaukee, Wis.
Power & Speed Controller Co., Boston, Mass.
Ward Leonard Elec. Co., Bronxville, N. Y.

Conveying Machinery.

Aultman Company, Canton, Ohio.
Borden & Selleck Co., Chicago, Ill.
Broderick & Bascom Rope Co., St. Louis, Mo.
Browning Engineering Co., Cleveland, O.
Buhl Malleable Co., Detroit, Mich.
H. W. Caldwell & Sons Co., Chicago, Ill.
Frick Company, Waynesboro, Pa.
Hayward Co., 97 Cedar St., New York.
C. W. Hunt Co., West New Brighton, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Arthur Koppel, 66 Broad St., New York.
A. Leschen & Sons Rope Co., St. Louis, Mo.
Lidgerwood Mfg. Co., 96 Liberty St., New York.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
John A. Mead Mfg. Co., 11 Broadway, New York.
Minneapolis Steel & Machinery Co., Minneapolis, Minn.
Robins Conveying Belt Co., 14-22 Park Row, N. Y.
Trenton Iron Co., Trenton, N. J.

Cooling Towers.

Alberger Condenser Co., 95 Liberty St., New York.
Wheeler Condenser & Engineering Co., 120 Liberty St., New York.
Henry R. Worthington, New York City.

For Alphabetical Index to Advertisers see inside back cover.

Copper.
Orford Copper Co., 74 Broadway, New York.

Cornices.
G. Drouvé & Co., Bridgeport, Conn.

Corrugated Iron.
Garry Iron & Steel Co., Cleveland, Ohio.

Cost Systems.
Baker-Vawter Co., Chicago, Ill.
Cost-System & Auditing Co., 45 B'way, New York.
Hugo Diemer, Lawrence, Kansas.
Gunn & Richards, 30 Pine St., New York.
David Townsend, 624 Witherspoon Bldg., Phila., Pa.

Counting Machines.
W. N. Durant Co., 235 22d St., Milwaukee, Wis.

Crane Motors.
Northern Electrical Mfg. Co., Madison, Wis.

Cranes.
American Hoist & Derrick Co., St. Paul, Minn.
Browning Engineering Co., Cleveland, Ohio.
Chicago Pneumatic Tool Co., Chicago, Ill.
Case Mfg. Co., Columbus, Ohio.
Garry Iron & Steel Co., Cleveland, Ohio.
Hayward Co., 97 Cedar St., New York.
Industrial Works, Bay City, Mich.
Niles-Bement-Pond Co., 136 Liberty St., New York.
The S. Obermayer Co., Cincinnati, Ohio.
Pedrick & Ayer Co., Philadelphia, Pa.
Riter-Conley Mfg. Co., Pittsburg, Pa.
Wm. Sellers & Co., Philadelphia, Pa.
Shaw Electric Crane Co., Muskegon, Mich.
R. D. Wood & Co., Philadelphia, Pa.

Creosoting.
Samuel Cabot, 70 Kilby St., Boston, Mass.

Crucibles.
F. W. Braun & Co., Los Angeles, Cal.
Jos. Dixon Crucible Co., Jersey City, N. Y.
The S. Obermayer Co., Cincinnati, Ohio.

Crushers—Ore, Phosphate, Rock.
Allis-Chalmers Co., Chicago, Ill.
Aultman Company, Canton, Ohio.
F. W. Braun Co., Los Angeles, Cal.
Card & Weber Machine Co., Denver, Colo.
Diamond Drill & Machine Co., Birdsboro, Pa.
Harron, Rickard & McCone, 21 Fremont St., San Francisco, Cal.
F. L. Smidth & Co., 66 Maiden Lane, New York.
E. H. Stroud & Co., Chicago, Ill.
Sturtevant Mill Co., Boston, Mass.

Crusher Rings and Shells (Steel).
Latrobe Steel Co., Philadelphia, Pa.

Cupel Machines.
F. W. Braun Co., Los Angeles, Cal.

Cupolas.
Northern Engineering Works, Detroit, Mich.
The S. Obermayer Co., Cincinnati, Ohio.
Riter-Conley Mfg. Co., Pittsburg, Pa.
F. B. Stevens, Detroit, Mich.

Cutters, Milling.
Becker-Brainard Milling Machine Co., Hyde Park, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Standard Tool Co., Cleveland, Ohio.

Diamond Drills.
American Diamond Rock Drill Co., 95 Liberty St., New York.
American Well Works, Aurora, Ill.
Davis Calyx Drill Co., 128 Broadway, New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Rand Drill Co., 128 Broadway, New York.

Digesters.
Atlantic Works, East Boston, Mass.
Riter-Conley Mfg. Co., Pittsburg, Pa.
Robt. Wetherill & Co., Chester, Pa.

Draught Gauges.
Hohmann & Maurer Mfg. Co., Rochester, N. Y.

Draftsmen's Instruments and Materials.
Theo. Altenedер & Sons, Philadelphia, Pa.
Brandis Sons Co., Brooklyn, N. Y.
Brown & Sharpe Mfg. Co., Providence, R. I.
Buff & Buff Mfg. Co., J. Plain Sta., Boston, Mass.
Eugene Dietzgen Co., 181 Monroe St., Chicago, Ill.
Keuffel & Esser Co., 127 Fulton St., New York.
Universal Drafting Machine Co., 220 Seneca St., Cleveland, Ohio.

Drawing Tables.
American Drafting Furniture Co., Rochester, N. Y.

Dredges—SEE EXCAVATORS.

Drilling Machines.
W. F. & John Barnes Co., Rockford, Ill.
Baush Machine Tool Co., Springfield, Mass.
Bickford Drill & Tool Co., Cincinnati, Ohio.
Chicago Pneumatic Tool Co., Chicago, Ill.
Cleveland Punch & Shear Works, Cleveland, Ohio.
Thos. H. Dallett & Co., Philadelphia, Pa.
Diamond Drill & Machine Co., Birdsboro, Pa.
Hisey-Wolf Machine Co., Cincinnati, O.
Philadelphia Pneumatic Tool Co., Philadelphia, Pa.
Pond Machine Tool Co., Plainfield, N. J.
Pratt & Whitney Co., Hartford, Conn.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.

Drills—Rock and Coal.
American Diamond Rock Drill Co., 95 Liberty St., New York.
Clayton Air Compress Wks., 120 Liberty St., N. Y.
Davis Calyx Drill Co., 128 Broadway, New York.
Hall Steam Pump Co., Pittsburg, Pa.
Harron, Rickard & McCone, 21 Fremont St., San Francisco, Cal.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Jeffrey Mfg. Co., Columbus, Ohio.
Rand Drill Co., 128 Broadway, New York.
Standard Diamond Drill Co., 108 La Salle St., Chicago, Ill.

Drop Forging Machinery.
Scranton & Co., 39 Church St., New Haven, Conn.

Drop Forgings.
Globe Machine & Stamping Co., Cleveland, Ohio.

Drying and Calcining Machines.
American Blower Co., Detroit, Mich.
Harrison Safety Boiler Works, 3138 N. 17th St., Philadelphia, Pa.
Jeffrey Mfg. Co., Columbus, Ohio.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.

Dynamos.
American Engine Co., Bound Brook, N. J.
Bullock Electric Mfg. Co., Cincinnati, Ohio.
Christensen Engineering Co., Milwaukee, Wis.
Crocker-Wheeler Co., Ampere, N. J.
C & C Electric Co., 143 Liberty St., New York.
Guarantee Electric Co., Chicago, Ill.
General Electric Co., New York.
Juntz & Leist Electric Co., Cincinnati, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
National Electric Co., Milwaukee Wis.
Northern Electrical Mfg. Co., Madison, Wis.
Robbins & Myers Co., Springfield, Ohio.
Sprague Electric Co., 527 W. 34th St., New York.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Ejectors.
Hancock Inspirator Co., 85 Liberty St., New York.
Hayden & Derby Mfg. Co., New York.
Watson & McDaniel Co., Philadelphia, Pa.

Electric Clocks.
E. Imhauser & Co., 206 Broadway, New York.

Electric Counters.
W. N. Durant Co., 235 22d St., Milwaukee, Wis.

Electric Hoists.
Browning Engineering Co., Cleveland, O.
C & C Electric Co., New York, N. Y.
C. W. Hunt Co., West New Brighton, N. Y.
Lambert Hoisting Engine Co., Newark, N. J.
Lidgerwood Mfg. Co., 96 Liberty St., New York.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Northern Engineering Works, Detroit, Mich.
Shaw Electric Crane Co., Muskegon, Mich.
Sprague Electric Co., 527-531 W. 34th St., N. Y.

Electric Heating Apparatus.
Simplex Electric Heating Co., Cambridgeport, Mass.

Electrical Machinery and Supplies.
American Engine Co., Bound Brook, N. J.
Geo. F. Blake Mfg. Co., 114 Liberty St., New York.
Bristol Co., Waterbury, Conn.
Broderick & Bascom Rope Co., St. Louis, Mo.
Bullock Electric Mfg. Co., Cincinnati, Ohio.
C & C Electric Co., 143 Liberty St., New York.

For Alphabetical Index to Advertisers see inside back cover.

Christensen Engineering Co., Milwaukee, Wis.
Crocker-Wheeler Co., Ampere, N. J.
The Cutter Co., Philadelphia, Pa.
The Cutler-Hammer Mfg. Co., Milwaukee, Wis.
Deane Steam Pump Co. of Holyoke, 116 Liberty St., New York.
General Electric Co., New York.
Hisey-Wolf Machine Co., Cincinnati, O.
Jantz & Leist Electric Co., Cincinnati, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Knowles Steam Pump Wks., 114 Liberty St., N. Y.
Laidlaw-Dunn-Gordon Co., 116 Liberty St., N. Y.
National Electric Co., Milwaukee, Wis.
Northern Electrical Mfg. Co., Madison, Wis.
Wm. E. Quimby, Inc., 86 Liberty St., New York.
Quincy Engine Works, Quincy, Ill.
The Robbins & Myers Co., Springfield, Ohio.
Snow Steam Pump Works, 116 Liberty St., N. Y.
Sprague Electric Co., 527 W. 34th St., New York.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.
Triumph Electric Co., Cincinnati, Ohio.
Ward Leonard Electric Co., Bronxville, N. Y.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.
Weston Elec. Inst. Co., Waverly Pk., Essex Co., N.J.
Henry R. Worthington, 118 Liberty St., New York.

Elevators.

American Tool & Machine Co., Boston, Mass.
Aultman Co., Canton, Ohio.
Borden & Selleck Co., Chicago, Ill.
Buhl Malleable Co., Detroit, Mich.
H. W. Caldwell & Sons Co., Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
John A. Mead Mfg. Co., 11 Broadway, New York.
Minneapolis Steel & Machinery Co., Minneapolis, Minn.
Morse Elevator Works, Philadelphia, Pa.
The S. Obermayer Co., Cincinnati, Ohio.
Poole Engineering & Machine Co., Baltimore, Md.
Triumph Electric Co., Cincinnati, Ohio.

Emery Wheel Dressers.

Globe Machine & Stamping Co., Cleveland, Ohio.

Emery Wheels.

Carborundum Co., Niagara Falls, N. Y.
Frank Machinery Co., Buffalo, N. Y.
Stow Flexible Shaft Co., Philadelphia, Pa.

Employment Bureau.

Engineering Agency, Monadnock Blk., Chicago, Ill.
Hapgoods, 309 Broadway, New York.

Engineering Instruments.

Theo. Alteneder & Sons, Philadelphia, Pa.
Brandis Sons Co., Brooklyn, N. Y.
Buff & Buff Mfg. Co., Boston, Mass.
Eugene Dietzgen Co., Chicago, Ill.
Keuffel & Esser Co., New York City.
Young & Sons, Philadelphia, Pa.

Engineers, Civil.

Engineering Co. of America, 74 B'way, New York.
Robert W. Hunt & Co., 1121 The Rookery, Chicago, Ill.
Chas. C. Moore & Co., San Francisco, Cal.
Sydney F. Reynolds, Torrey, Pa.
A. W. Robinson, Montreal, Canada.

Engineers, Electrical.

Crocker-Wheeler Co., Ampere, N. J.
Engineering Co. of America, 74 B'way, New York.
Robt. McF. Doble, 314 Hayward Bldg., San Francisco, Cal.
W. K. Palmer, 401 N. Y. Life Bldg., Kansas City, Mo.
Sydney F. Reynolds, Torrey, Pa.
Philip K. Stern, 130 Fulton St., New York.

Engineers, Mechanical.

William M. Brewer, Vancouver, B. C.
Geo. M. Brill, Marquette Bldg., Chicago, Ill.
Edward S. Cobb., Los Angeles, Cal.
Engineering Co. of America, 74 B'way, New York.
Hugo Diemer, Lawrence, Kans.
Robt. McF. Doble, 314 Hayward Bldg., San Francisco, Cal.
Alfred G. Heggem, Massillon, Ohio.
Holt & Schober, 378 Bourse, Philadelphia, Pa.
Julian Kennedy, Pittsburg, Pa.
Walter Kennedy, Pittsburg, Pa.
G. W. McClure, Son & Co., Pittsburg, Pa.
Milton L. Oglesby, David Keith Bldg., Salt Lake City, Utah.
W. K. Palmer, 401 N. Y. Life Bldg., Kansas City, Mo.
C. L. Redfield, 1563 Monadnock Block, Chicago, Ill.
Sydney F. Reynolds, Torrey, Pa.
A. W. Robinson, Montreal, Canada.
H. B. Roelker, 41 Maiden Lane, New York.
Chas. S. Sage, Wellsville, N. Y.
Philip K. Stern, 130 Fulton St., New York.
David Townsend, 624 Witherspoon Bldg., Phila., Pa.

Engineers, Mining.

William M. Brewer, Vancouver, B. C.
Chas. Catlett, Staunton, Va.
L. B. Darling, Providence, R. I.
Engineering Co. of America, 74 B'way, New York.
Henshaw, Bulkley & Co., San Francisco, Cal.
Bernard MacDonald, Spokane, Wash.
Milton L. Oglesby, David Keith Bldg., Salt Lake City, Utah.
Sydney F. Reynolds, Torrey, Pa.

Engines, Blowing.

Allis-Chalmers Co., Chicago, Ill.
American Blower Co., Detroit, Mich.
Sprague Electric Co., 527 W. 34th St., New York.
Southwark Foundry & Machine Co., Phila., Pa.
Wm. Tod Co., Youngstown, O.

Engines—Gas, Gasoline, and Petroleum.

American Well Works, Aurora, Ill.
Aultman Company, Canton, Ohio.
Borden & Selleck Co., Chicago, Ill.
General Power Co., 81-83 Fulton St., New York.
Hercules Gas Engine Works, 217 Bay St., San Francisco, Cal.
J. D. Lyon & Co., Pittsburg, Pa.
Machinery & Electrical Co., Los Angeles, Cal.
August Mietz, 128 Mott St., New York.
Northern Engineering Works, Detroit, Mich.
Struthers-Wells Company, Warren, Pa.
Weber Gas & Gasoline Engine Co., Kansas City, Mo.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Engines, Marine.

August Mietz, 128 Mott St., New York.

Engines, Steam.

Allis-Chalmers Co., Chicago, Ill.
American Blower Co., Detroit, Mich.
American Engine Co., Bound Brook, N. J
American Well Works, Aurora, Ill.
Atlas Engine Co., Indianapolis, Ind.
Aultman Company, Canton, Ohio.
Ball Engine Co., Erie, Pa.
Ball & Wood Co., 17 Battery Place, New York.
A. F. Bartlett & Co., Saginaw, Mich.
Bradley Mfg. Co., Allegheny, Pa.
Brown Corliss Engine Co., Corliss, Wis.
Contractors' Supply & Equipment Co., Chicago, Ill.
Erie Pump & Engine Co., Erie, Pa.
Frick Company, Waynesboro, Pa.
Harrisburg Foundry & Machine Co., Harrisburg, Pa.
Harron, Rickard & McCone, 21 Fremont St., San Francisco, Cal.
Hooven, Owens, Rentschler Co., Hamilton, Ohio.
S. W. Luitwieler Co., Los Angeles, Cal.
P. B. McCabe & Co., 602 No. Main St., Los Angeles, Cal.
Minneapolis Steel & Machinery Co., Minneapolis, Minn.
Providence Engineering Works, Providence, R. I.
Quincy Engine Works, Quincy, Ill.
Reeves Engine Co., 85 Liberty St., New York.
Rider-Ericsson Engine Co., New York City.
Rotary Engine Co., Philadelphia, Pa.
Shepherd Engineering Co., Franklin, Pa.
Skinner Engine Co., Erie, Pa.
Southwark Foundry & Machine Co., Phila., Pa.
Struthers-Wells Company, Warren, Pa.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.
The William Tod Co., Youngstown, Ohio.
Vulcan Iron Works, San Francisco, Cal.
Webster, Camp & Lane Machine Co., Cleveland, O.
Willamette Iron & Steel Co., Portland, Ore.
Robt. Wetherill & Co., Chester, Pa.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Evaporators.

Wheeler Condenser & Engineering Co., 120 Liberty St., New York.

Excavators.

Atlantic, Gulf & Pacific Co., Park Row Bldg., N. Y.
Broderick & Bascom Rope Co., St. Louis, Mo.

For Alphabetical Index to Advertisers see inside back cover.

Bucyrus Co., So. Milwaukee, Wis.
The Hayward Co., 97 Cedar St., New York.
Kingsford Fdy. & Mch. Works, Oswego, N. Y.
Jeffrey Mfg. Co., Columbus, Ohio.
A. Leschen & Sons Rope Co., St. Louis, Mo.
Marion Steam Shovel Co., Marion, Ohio.
Robins Conveying Belt Co., 14-22 Park Row, N. Y.
Vulcan Iron Works, Toledo, Ohio.

Exhaust Heads.
Direct Separator Co., Syracuse, N. Y.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City.
Hoppes Mfg. Co., Springfield, Ohio.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.
Watson & McDaniel Co., Philadelphia, Pa.
Wright Mfg. Co., Detroit, Mich.

Fans, Ventilating.
Allis-Chalmers Co., Chicago, Ill.
American Blower Co., Detroit, Mich.
Harron, Rickard & McCone, San Francisco, Cal.
Power Specialty Co., 120 Liberty St., New York.
Sprague Electric Co., 527 W. 34th St., New York.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.

Feed-Water Heaters and Purifiers.
Allis-Chalmers Co., Chicago, Ill.
G. M. Davis Regulator Co., 144 Milwaukee Ave., Chicago, Ill.
Goubert Mfg. Co., 85 Liberty St., New York.
Green Fuel Economizer Co., Matteawan, N. Y.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City.
Harron, Rickard & McCone, San Francisco, Cal.
Harrison Safety Boiler Works, 3138 N. 17th St., Philadelphia, Pa.
Hoppes Manufacturing Co., Springfield, Ohio.
John H. McGowan Co., Cincinnati, Ohio.
National Pipe Bending Co., New Haven, Conn.
Providence Engineering Works, Providence, R. I.
Ross Valve Co., Troy, N. Y.
Wm. B. Scaife & Sons Co., Pittsburg, Pa.
Stewart Heater Co., Buffalo, N. Y.
Warren Webster & Co., Camden, N. J.
Robt. Wetherill & Co., Chester, Pa.
Wheeler Condenser & Engineering Co., 120 Liberty St., New York.

Fertilizer Machinery.
Aultman Company, Canton, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
E. H. Stroud & Co., Chicago, Ill.

Files and Rasps.
G. & H. Barnett Co., Philadelphia, Pa.
Nicholson File Co., Providence, R. I.

Filters.
L. O. Koven & Bro., New York City.
New York Cont. Jewell Filt. Co., 15 Broad St., N. Y.
Ross Valve Co., Troy, N. Y.
Wm. B. Scaife & Sons Co., Pittsburg, Pa.
Robt. Wetherill & Co., Chester, Pa.

Fire Brick.
Henry Maurer & Son, 420 East 23d St., New York.
S. Obermayer Co., Cincinnati, Ohio.

Fireproof Building Materials.
Henry Maurer & Son, 420 East 23d St., New York.
National Fireproofing Co., Pittsburg, Pa.
Roebling Construction Co., 121 Liberty St., N. Y.

Filing Cabinets.
American Drafting Furniture Co., Rochester, N. Y.

Flanges.
E. M. Dart Mfg. Co., 156 Clifford St., Providence, R. I.
Jefferson Mfg. Co., Lexington, Mass.
Latrobe Steel Co., 1200 Girard Bldg., Phila., Pa.

Flanges (Weldless Steel).
Latrobe Steel Co., 1200 Girard Bldg., Phila., Pa.

Flexible Shafts.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.

Floor and Sidewalk Lights.
T. H. Brooks & Co., Cleveland, Ohio.

Flooring, Factory.
American Lumber & Mfg. Co., Pittsburg, Pa.
U. S. Wood Preserving Co., 29 B'way, New York.

Flour Tallies.
W. N. Durant Co., 235 22d St., Milwaukee, Wis.

Flue Scrapers.
Eagle Oil & Supply Co., 104 Broad St., Boston, Mass.
Wm. B. Pierce Co., Buffalo, N. Y.

Fly Wheels.
Allis-Chalmers Co., Chicago, Ill.
Poole Engineering & Machine Co., Baltimore, Md.
Quincy Engine Works, Quincy, Ill.
S. Morgan Smith Co., York, Pa.
Robt. Wetherill & Co., Chester, Pa.

Forges.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.

Forging Machinery.
Scranton & Co., 39 Church St., New Haven, Conn.

Forgings, Iron and Steel.
Chester B. Albree, Allegheny, Pa.
Keystone Drop Forge Works, Philadelphia, Pa.
Maryland Steel Co., Sparrows Point, Md.
E. M. Shaw, Providence, R. I.
Pennsylvania Steel Co., Steelton, Pa.
Wyman & Gordon, Worcester, Mass.

Foundry Equipment.
Blanchard Machine Co., Boston, Mass.
Buffalo Foundry Co., Buffalo, N. Y.
Diamond Drill & Machine Co., Birdsboro, Pa.
A. Garrison Foundry Co., Pittsburg, Pa.
C. W. Hunt Co., West New Brighton, N. Y.
Arthur Koppel, 68 Broad St., New York.
Northern Engineering Works, Detroit, Mich.
S. Obermayer Co., Cincinnati, Ohio.
Pedrick & Ayer Co., Philadelphia, Pa.
Shaw Electric Crane Co., Muskegon, Mich.
F. B. Stevens, Detroit, Mich.

Friction Clutches.
American Tool & Machine Co., Boston, Mass.
H. W. Caldwell & Sons Co., Chicago, Ill.
Case Mfg. Co., Columbus, Ohio.
Dodge Mfg. Co., Mishawaka, Ind.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
Poole Engineering & Machine Co., Baltimore, Md.
S. Morgan Smith Co., York, Pa.

Fuel Economizers.
Green Fuel Economizer Co., Matteawan, N. Y.
Parson Mfg. Co., 320 Broadway, New York.
Providence Engineering Works, Providence, R. I.
Steam Boiler Equipment Co., 30 W. Houston St., New York.
E. H. Stroud & Co., Chicago, Ill.

Furnace Builders.
American Gas Furnace Co., 23 John St., New York.
Continental Iron Wks., West & Calyer Sts., Brooklyn, N. Y.
Julian Kennedy, Pittsburg, Pa.
G. W. McClure, Son & Co., Smith Block, Pittsburg, Pa.
Morgan Construction Co., Worcester, Mass.
Parson Mfg. Co., 320 Broadway, New York.
Ritter-Conley Mfg. Co., Pittsburg, Pa.
Waterbury Farrel Foundry & Machine Co., Waterbury, Conn.

Furnaces, Assayers.
F. W. Braun & Co., Los Angeles, Cal.

Gages—Pressure, Steam, Water, etc.
American Steam Gauge & Valve Co., Boston, Mass.
Ashcroft Mfg. Co., 85-89 Liberty St., New York.
Bristol Co., Waterbury, Conn.
Crosby Steam Gage & Valve Co., Boston, Mass.
Hohmann & Maurer Mfg. Co., Rochester, N. Y.
John Simmons Co., 110 Centre St., New York.
Standard Gauge Mfg. Co., Syracuse, N. Y.
Star Brass Mfg. Co., Boston, Mass.
Walworth Manufacturing Co., Boston, Mass.

Galvanizing.
L. O. Koven & Bro., New York City.
John Simmons Co., 110 Centre St., New York.

Galvanizing Machinery and Furnaces (Wire).
Turner, Vaughn & Taylor Co., Cuyahoga Falls, O.

Gas Holders and Regulators.
Continental Iron Wks., West & Calyer Sts., Brooklyn, N. Y.
Ritter-Conley Mfg. Co., Pittsburg, Pa.

Gaskets.
Boston Belting Co., Boston, Mass.
Eagle Oil & Supply Co., 104 Broad St., Boston, Mass.
U. S. Mineral Wool Co., 143 Liberty St., New York.

For Alphabetical Index to Advertisers see inside back cover.

Gas Machines and Generators.

American Gas Furnace Co., 23 John St., New York.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
Loomis-Pettibone Gas Mchy. Co., 52 William St., New York.
Morgan Construction Co., Worcester, Mass.
R. D. Wood & Co., Philadelphia, Pa.
Walworth Manufacturing Co., Boston, Mass.

Gas Washer.

Kloman Co., Pittsburg, Pa.

Gear Cutting Machines.

Becker-Brainard Milling Machine Co., Hyde Park, Mass.
Gould & Eberhardt, Newark, N. J.

Gearing.

Allis-Chalmers Co., Chicago, Ill.
Hugo Bilgram, 440 No. 12th St., Philadelphia, Pa.
Boston Gear Works, Boston, Mass.
Geo. F. Blake Mfg. Co., 91 Liberty St., New York.
Brown & Sharpe Mfg. Co., Providence, R. I.
Buhl Malleable Co., Detroit, Mich.
H. W. Caldwell & Son Co., Chicago, Ill.
Case Mfg. Co., Columbus, Ohio.
Dayton Globe Iron Works Co., Dayton, O.
Dodge Mfg. Co., Mishawaka, Ind.
Gould & Eberhardt, Newark, N. J.
Jeffrey Mfg. Co., Columbus, Ohio.
Knowles Steam Pump Wks., 91 Liberty St., N. Y.
Morse Elevator Works, Philadelphia, Pa.
New Process Rawhide Co., Syracuse, N. Y.
R. D. Nuttall Co., Pittsburg, Pa.
Poole Engineering & Machine Co., Baltimore, Md.
William Sellers & Co., Inc., Philadelphia, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.
Robt. Wetherill & Co., Chester, Pa.

Grain Elevator Machinery.

Allis-Chalmers Co., Chicago, Ill.
Aultman Co., Canton, Ohio.
Dodge Mfg. Co., Mishawaka, Ind.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
Riter-Conley Mfg. Co., Pittsburg, Pa.
Robins Conveying Belt Co., 14-22 Park Row, N. Y.

Graphite.

Jos. Dixon Crucible Co., Jersey City, N. J.
The S. Obermayer Co., Cincinnati, Ohio.

Grinders, Electric.

Northern Electrical Mfg. Co., Madison, Wis.

Grinding and Polishing Machinery.

Brown & Sharpe Mfg. Co., Providence, R. I.
Diamond Machine Co., Providence, R. I.
Dodge Mfg. Co. Mishawaka, Ind.
Harron, Rickard & McCone, San Francisco, Cal.
Hisey-Wolf Machine Co., Cincinnati, Ohio.
Landis Tool Co., Waynesboro, Pa.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Pratt & Whitney Co., Hartford, Conn.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
F. L. Smidth & Co., 65 Maiden Lane, New York.
Stow Flexible Shaft Co., Philadelphia, Pa.

Hangers—SEE PULLEYS.

Heading and Upsetting Machines.

National Machinery Co., Tiffin, Ohio.

Heating and Ventilating Apparatus.

American Blower Co., Detroit, Mich.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City.
Hayden & Derby Mfg. Co., New York.
John Simmons Co., 110 Centre St., New York.
Sprague Electric Co., 527 W. 34th St., New York.
H. B. Smith Co., 137 Centre St., New York.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.
Walworth Mfg. Co., Boston, Mass.

Hoisting Engines and Machinery.

Allis-Chalmers Co., Chicago, Ill.
Aultman Company, Canton, Ohio.
A. F. Bartlett & Co., Saginaw, Mich.
Brown Hoisting Machinery Co,, 26 Cortlandt St., New York.
Browning Engineering Co., Cleveland, Ohio.
Chicago Pneumatic Tool Co., Chicago, Ill.
Contractors' Plant Mfg. Co., Buffalo, N. Y.
Contractors' Supply & Equipment Co., Chicago, Ill.
Cooper, Hewitt & Co., 17 Burling Slip, New York.
General Power Co., 81-83 Fulton St., New York.
Harron, Rickard & McCone, 21 Fremont St., San Francisco, Cal.
The Hayward Co., 97 Cedar St., New York.
Hendrie & Bolthoff Mfg. & Supply Co., 1601 Seventeenth St., Denver, Colo.
C. W. Hunt Co., West New Brighton, New York.
Industrial Works, Bay City, Mich.
Jeffrey Mfg. Co., Columbus, Ohio.
Lambert Hoisting Engine Co., Newark, N. J.
A. Leschen & Sons Rope Co., St. Louis, Mo.
Lidgerwood Mfg. Co., 96 Liberty St., New York.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
Machinery & Electrical Co., Los Angeles, Cal.
P. B. McCabe & Co., 602 No. Main St., Los Angeles, Cal.
John A. Mead Mfg. Co., 11 Broadway, New York.
Niles Tool Works Co., Hamilton, Ohio.
Northern Engineering Works, Detroit, Mich.
Providence Engineering Works, Providence, R. I.
Quincy Engine Works, Quincy, Ill.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Sprague Electric Co., 527-531 W. 34th St., N. Y.
G. L. Stuebner, Long Island City, N. Y.
Trenton Iron Co., Trenton, N. J.
Webster, Camp & Lane Machine Co., Cleveland, O.
Weber Gas & Gasoline Engine Co., Kansas City, Mo.

Hollow Chisel Mortisers.

J. A. Fay & Egan Co., 212-232 West Front St., Cincinnati, Ohio.

Hose.

Boston Belting Co., Boston, Mass.
Eagle Oil & Supply Co., 104 Broad St., Boston, Mass.
Eureka Fire Hose Co., New York City.

Hydraulic Machinery.

Detroit Leather Specialty Co., Detroit, Mich.
Harron, Rickard & McCone, San Francisco, Cal.
John H. McGowan Co., Cincinnati, Ohio.
S. Morgan Smith Co., York, Pa.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Pelton Water Wheel Co., San Francisco, Cal.
Poole Engineering & Machine Co., Baltimore, Md.
Power Specialty Co., 126 Liberty St., New York.
Waterbury Farrel Foundry & Machine Co., Waterbury, Conn.
Watson-Stillman Co., 240 E. 43d St., New York.
R. D. Wood & Co., Philadelphia, Pa.

Hydraulic Rams.

Pelton Water Wheel Co., San Francisco, Cal.
Power Specialty Co., 126 Liberty St. New York.

Ice-Making and Refrigerating Machinery.

Geo. F. Blake Mfg. Co., 114 Liberty St., New York.
Deane Steam Pump Co. of Holyoke, 116 Liberty St., New York.
Frick Company, Waynesboro, Pa.
Knowles Steam Pump Wks., 114 Liberty St., N. Y.
Laidlaw-Dunn-Gordon Co., 116 Liberty St., N. Y.
Penna. Iron Wks. Co., 50th St. & Lancaster Ave., Philadelphia, Pa.
H. B. Roelker, 43 Maiden Lane, New York.
Snow Steam Pump Works, 116 Liberty St., N. Y.
Vulcan Iron Works, San Francisco, Cal.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.
Henry R. Worthington, 118 Liberty St., New York.

Injectors.

Hayden & Derby Mfg. Co., New York.
The Lunkenheimer Co., Cincinnati, Ohio.
John Simmons Co., 110 Centre St., New York.
Wm. Sellers & Co., Philadelphia, Pa.

Insulated Wire.

General Electric Co., New York.
Sprague Electric Co., 527 W. 34th St., New York.

Insulating Materials.

Sterling Varnish Co., Pittsburg, Pa.

Internal Gearing.

R. D. Nuttall Co., Pittsburg, Pa.

For Alphabetical Index to Advertisers see inside back cover.

Jacks.
Atlas Railway Supply Co., Manhattan Bldg., Chicago, Ill.

Jacks, Hydraulic.
Watson-Stillman Co., New York City.

Jet Apparatus.
Hayden & Derby Mfg. Co., New York.

Kiers.
Atlantic Works, East Boston, Mass.

Laboratory Supplies.
F. W. Braun & Co., Los Angeles, Cal.

Lamps, Electric.
General Electric Co., New York.
Sterling Electrical Mfg. Co., Warren, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Lathes.
American Tool & Machine Co., Boston, Mass.
W. F. & John Barnes Co., Rockford, Ill.
Bullard Machine Tool Co., Bridgeport, Conn.
Diamond Machine Co., Providence, R. I.
Fay & Scott, Dexter, Me.
A. Garrison Foundry Co., Pittsburg, Pa.
Jones & Lamson Machine Co., Springfield, Vt.
Miami Valley Machine Tool Co., Dayton, O.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Pond Machine Tool Co., Plainfield, N. J.
Pratt & Whitney Co., Hartford, Conn.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Waterbury Farrel Foundry & Machine Co., Waterbury, Conn.

Leather, Hydraulic, Valve and Pump.
Detroit Leather Specialty Co., Detroit, Mich.
Chas. A. Schieren & Co., 45-51 Ferry St., New York.

Light Railways.
C. W. Hunt Co., West New Brighton, New York.
Arthur Koppel, 68 Broad St., New York.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
John A. Mead Mfg. Co., 11 Broadway, New York.
G. L. Stuebner, Long Island City, N. Y.

Lockers.
Merritt & Co., Philadelphia, Pa.

Locomotive Cranes.
Browning Engineering Co., Cleveland, Ohio.
Industrial Works, Bay City, Mich.

Locomotives, Compressed Air.
Baldwin Locomotive Works, Phila, Pa.
H. K. Porter Co., Pittsburg, Pa.

Locomotives, Electric.
Baldwin Locomotive Works, Philadelphia, Pa.
Crocker-Wheeler Co., Ampere, N. J.
General Electric Co., New York.
C. W. Hunt Co., West New Brighton, N. Y.
Jeffrey Mfg. Co., Columbus, Ohio.
Arthur Koppel, 68 Broad St., New York.
H. K. Porter Co., Pittsburg, Pa.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Locomotives, Steam.
American Locomotive Co., 25 Broad St., New York.
Baldwin Locomotive Works, Philadelphia, Pa.
Contractors' Supply & Equipment Co., Chicago, Ill.
Lima Locomotive & Machine Co., Lima, Ohio.
H. K. Porter Co., Pittsburg, Pa.
Rogers Locomotive Works, Paterson, N. J.

Loose Leaf Files.
Tengwall File & Ledger Co., Chicago, Ill.

Loose Leaf Ledgers.
Tengwall File & Ledger Co., Chicago, Ill.

Lubricants.
Jos. Dixon Crucible Co., Jersey City, N. J.
Eagle Oil & Supply Co., 104 Broad St., Boston, Mass.

Lubricating and Oiling Devices.
E. M. Dart Mfg. Co., 136 Clifford St., Providence, R. I.
Harron, Rickard & McCone, San Francisco, Cal.

Machinery Exhibit.
Bourse, Philadelphia, Pa.

Machine Shop Furniture.
Lyon Metallic Mfg. Co., 18 S. Ann St., Chicago, Ill.

Machinists' Small Tools.
Brown & Sharpe Mfg. Co., Providence, R. I.
Thomas H. Dallett Co., York St. & Sedgley Ave., Philadelphia, Pa.
Morse Twist Drill & Mch. Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Standard Tool Co., Cleveland, Ohio.

Manufacturers' Export Representative.
M. Gradstone & Co., 2-4 Stone St., New York.

Metal Polish.
Eagle Oil & Supply Co., 104 Broad St., Boston, Mass.

Meters, Electric.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
Weston Elec. Inst. Co., Waverly Pk., Essex Co., N.J.

Milling Machines.
Adams Company, Dubuque, Iowa.
American Tool & Machine Co., Boston, Mass.
Becker-Brainard Milling Machine Co., Hyde Park, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Harron, Rickard & McCone, 21 Fremont St., San Francisco, Cal.
Hendrie & Bolthoff Mfg. & Supply Co., Denver, Colo.
Henshaw, Bulkley & Co., San Francisco, Cal.
Hess Machine Co., 15th and Chestnut Sts., Philadelphia, Pa.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Pratt & Whitney Co., Hartford, Conn.

Milling Tools.
Harron, Rickard & McCone, 21 Fremont St., San Francisco, Cal.

Mill Supplies.
Eagle Oil & Supply Co., 104 Broad St., Boston, Mass.
Harron, Rickard & McCone, San Francisco, Cal.
Phillips Mine & Mill Supply Co., Pittsburg, Pa.

Mine Cars.
Allis-Chalmers Co., Chicago.
C. W. Hunt Co., West New Brighton, N. Y.
Engineering Works of Wonham-Magor, 29 Broadway, New York.
Jeffrey Manufacturing Co., Columbus, Ohio.
Kilbourne & Jacobs Mfg. Co., Columbus, O.
Arthur Koppel, 68 Broad St., New York.
Lima Locomotive and Machine Co., Lima, O.
Watt Mining Car Wheel Co., Barnesville, Ohio.

Mining Machinery.
Allis-Chalmers Co., Chicago, Ill.
American Diamond Rock Drill Co., 95 Liberty St., New York.
A. F. Bartlett & Co., Saginaw, Mich.
Geo. F. Blake Mfg. Co., 114 Liberty St., New York.
Broderick & Bascom Rope Co., St. Louis, Mo.
Buhl Malleable Co., Detroit, Mich.
A. S. Cameron Steam Pump Wks., E. 23d St., N. Y.
Card & Weber Machine Co., Denver, Colo.
Contractors' Supply & Equipment Co., Chicago, Ill.
Davis Calyx Drill Co., 128 Broadway, New York.
Deane Steam Pump Co. of Holyoke, 116 Liberty St., New York.
Diamond Drill & Machine Co., Birdsboro, Pa.
General Electric Co., New York.
Harron, Rickard & McCone, 21 Fremont St., San Francisco, Cal.
Hendrie & Bolthoff Mfg. & Supply Co., Denver, Colo.
Henshaw, Bulkley & Co., San Francisco, Cal.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Jeffrey Mfg. Co., Columbus, Ohio.
Knowles Steam Pump Wks., 114 Liberty St., N. Y.
Arthur Koppel, 68 Broad St., New York.
Laidlaw-Dunn-Gordon Co., 116 Liberty St., N. Y.
Lambert Hoisting Engine Co., Newark, N. J.
A. Leschen & Sons Rope Co., St. Louis, Mo.
Lidgerwood Mfg. Co., 96 Liberty St., New York.
The Machinery & Electrical Co., Los Angeles, Cal.
Marion Steam Shovel Co., Marion, Ohio.
John H. McGowan Co., Cincinnati, Ohio.
Norwalk Iron Works, South Norwalk, Conn.
Phillips Mine & Mill Supply Co., Pittsburg, Pa.
Power Specialty Co., 126 Liberty St., New York.
Providence Engineering Works, Providence, R. I.
Quincy Engine Works, Quincy, Ill.
Rand Drill Co., 128 Broadway, New York.
Robins Conveying Belt Co., 14-22 Park Row, N. Y.

For Alphabetical Index to Advertisers see inside back cover.

F. L. Smidth & Co., 66 Maiden Lane, New York.
Snow Steam Pump Works, 116 Liberty St., N. Y.
E. H. Stroud & Co., Chicago, Ill.
Trenton Iron Works Co., Trenton, N. J.
Vulcan Iron Works, San Francisco, Cal.
Vulcan Iron Works Co., Toledo, Ohio.
Watt Mining Car Wheel Co., Barnesville, Ohio.
Webster, Camp & Lane Machine Co., Cleveland, O.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
Henry R. Worthington, 118 Liberty St., New York.

Mining Screens—SEE SCREENS.

Motors, Electric.

American Engine Co., Bound Brook, N. J.
Bullock Electric Mfg. Co., Cincinnati, Ohio.
C & C Electric Co., 145 Liberty St., New York.
Christensen Engineering Co., Milwaukee, Wis.
Crocker-Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Guarantee Electric Co., Chicago, Ill.
Jantz & Leist Electric Co., Cincinnati, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
National Electric Co., Milwaukee, Wis.
Northern Electrical Mfg. Co., Madison, Wis.
The Robbins & Myers Co., Springfield, Ohio.
Sprague Electric Co., 527 W. 34th St., New York.
Stow Mfg. Co., Binghamton, N. Y.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Moulding Machines.

Frank Machinery Co., Buffalo, N. Y.
S. Obermayer Co., Cincinnati, Ohio.
Pa.
Power Specialty Co., 126 Liberty St., New York.
Tabor Mfg. Co., Philadelphia, Pa.
Turner Machine Co., Philadelphia, Pa.

Muffles and Annealing Furnaces (Wire).

Turner, Vaughn & Taylor Co., Cuyahoga Falls, O.

Naphtha Gas Machines.

American Gas Furnace Co., 23 John St., New York.

Nickel.

Benedict & Burnham Mfg. Co., Waterbury, Conn.
Orford Copper Co., 74 Broadway, New York.

Nozzle and Sleeve Press.

Turner, Vaughn & Taylor Co., Cuyahoga Falls, O.

Nut Tappers.

National Machinery Co., Tiffin, Ohio.

Oak Timbers.

American Lumber & Mfg. Co., Pittsburg, Pa.

Office Equipment.

Globe-Wernicke Co., Cincinnati, Ohio.

Oil Burners.

C. A. Hammel, 120 W. Fifth St., Los Angeles, Cal.

Oil Filters.

Eagle Oil & Supply Co., 104 Broad St., Boston, Mass.
Pittsburg Gage & Supply Co., Pittsburg, Pa.

Oil Separators.

Austin Separator Co., Detroit, Mich.
Griffing Iron Co., Jersey City, N. J.
Harrison Safety Boiler Works, 3138 No. Seventeenth St., Philadelphia, Pa.

Open Hearth Furnaces.

G. W. McClure, Son & Co., Smith Block, Pittsburg, Pa.

Ore-Roasting Machinery.

Allis-Chalmers Co., Chicago, Ill.

Packing.

Boston Belting Co., Boston, Mass.
Broderick & Bascom Rope Co., St. Louis, Mo.
Detroit Leather Specialty Co., Detroit, Mich.
Eagle Oil & Supply Co., 104 Broad St., Boston, Mass.
Hileman-James Co., 523 Locust St., McKeesport, Pa.
Jenkins Brothers, 71 John St., New York.
A. Leschen & Sons Rope Co., St. Louis, Mo.
Mubbs Hydraulic Packing Co., Board of Trade, Chicago, Ill.

Paints and Varnishes.

Atlas Railway Supply Co., Chicago, Ill.
Detroit Graphite Mfg. Co., Detroit, Mich.
Joseph Dixon Crucible Co., Jersey City, N. J.
Garry Iron & Steel Co., Cleveland, Ohio.
Paraffine Paint Co., San Francisco, Cal.
Standard Paint Co., 100 William St., New York.
Sterling Varnish Co., Pittsburg, Pa.

Paper-Mill Machinery.

Aultman Company, Canton, Ohio.
Geo. F. Blake Mfg. Co., 114 Liberty St., New York.
Deane Steam Pump Co. of Holyoke, 116 Liberty St., New York.
Dodge Mfg. Co., Mishawaka, Ind.
Jeffrey Mfg. Co., Columbus, Ohio.
Knowles Steam Pump Wks., 114 Liberty St., N. Y.
Laidlaw-Dunn-Gordon Co., 116 Liberty St., N. Y.
Robins Conveying Belt Co., 14-22 Park Row, N. Y.
Snow Steam Pump Works, 116 Liberty St., N. Y.
Henry R. Worthington, 118 Liberty St., New York.

Patent Attorneys.

C. A. Dieterich, 257 Broadway, New York.
Evans, Wilkins & Co., Evans Building, Washington, D. C.
Philip K. Stern, 130 Fulton St., New York.

Pattern-Makers' Machinery.

J. A. Fay & Egan Co., 212-232 West Front St., Cincinnati, Ohio.
Fay & Scott, Dexter, Me.
Pratt & Whitney Co., Hartford, Conn.

Pattern Makers.

Buhl Malleable Co., Detroit, Mich.
Diamond Drill & Machine Co., Birdsboro, Pa.

Perforated Metal.

Robt. Aitchison Perforated Metal Co., Chicago, Ill.
Allis-Chalmers Co., Chicago, Ill.
H. W. Caldwell & Sons Co., Chicago, Ill.
Turner, Vaughn & Taylor Co., Cuyahoga Falls, O.

Phosphor Bronze.

Phosphor Bronze Smelting Co., Ltd., Phila., Pa.
Poole Engineering & Machine Co., Baltimore, Md.
Paul S. Reeves & Son., Philadelphia, Pa.

Pile Drivers.

Vulcan Iron Works, Chicago, Ill.

Pinions.

A. Garrison Foundry Co., Pittsburg, Pa.

Pipe.

American Spiral Pipe Works, Chicago, Ill.
Garry Iron & Steel Co., Cleveland, Ohio.
L. O. Koven & Bro., 50 Cliff St., New York.
McNab & Harlin Mfg. Co., 56-60 John St., N. Y.
Nason Mfg. Co., 71 Fulton St., New York.
National Pipe Bending Co., New Haven, Conn.
Pelton Water Wheel Co., San Francisco, Cal.
The Michigan Pipe Co., Bay City, Mich.
U. S. Cast Iron Pipe & Fdy. Co., Philadelphia, Pa.
U. S. Wind Engine & Pump Co., Batavia, Ill.

Pipe-Cutting and Threading Machines.

Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Cox & Sons Company, Bridgeton, N. J.
Harron, Rickard & McCone, San Francisco, Cal.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Pratt & Whitney Co., Hartford, Conn.
John Simmons Co., 110 Centre St., New York.
Walworth Manufacturing Co., Boston, Mass.

Pipe Fittings, Cast-Iron.

Kelly & Jones Co., Greensburg, Pa.
McNab & Harlin Mfg. Co., 56-60 John St., N. Y.
Pelton Water Wheel Co., San Francisco, Cal.
John Simmons Co., 110 Centre St., New York.
Walworth Manufacturing Co., Boston, Mass.
U. S. Wind Engine & Pump Co., Batavia, Ill.

Pipe Vises.

John Simmons Co., 110 Centre St., New York.

For Alphabetical Index to Advertisers see inside back cover.

Planers.

Cleveland Punch & Shear Works, Cleveland, Ohio.
Frank Machinery Co., Buffalo, N. Y.
Hilles & Jones Co., Wilmington, Del.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Pratt & Whitney Co., Hartford, Conn.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Whitcomb Mfg. Co., Worcester, Mass.

Planing Mill Machinery.

J. A. Fay & Egan Co., 212-232 West Front St., Cincinnati, Ohio.
Harron, Rickard & McCone, San Francisco, Cal.

Platinum Ware.

F. W. Braun Co., Los Angeles, Cal.

Pneumatic Tools.

Chicago Pneumatic Tool Co., Chicago, Ill.
Clayton Air Compress. Wks., 114 Liberty St., N. Y.
Cleveland Pneumatic Tool Co., Cleveland, Ohio.
Curtis & Co. Mfg. Co., St. Louis, Mo.
Thos. H. Dallett & Co., Philadelphia, Pa.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
E. W. Irwin Machinery & Supply Co., 114 Liberty St., New York.
Pedrick & Ayer Co., Philadelphia, Pa.
Philadelphia Pneumatic Tool Co., Philadelphia, Pa.
Rand Drill Co., 128 Broadway, New York.
Standard Railway Equipment Co., St. Louis, Mo.

Pop Safety Valves.

Consolidated Safety Valve Co., 85-89 Liberty St., New York.
Star Brass Mfg. Co., Boston, Mass.

Portable Drilling Machines.

Hisey-Wolf Machine Co., Cincinnati, Ohio.
Thos. H. Dallett & Co., Philadelphia, Pa.

Power Hammers.

Pratt & Whitney Co., Hartford, Conn.
Scranton & Co., 39 Church St., New Haven, Conn.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Power-Transmission Machinery.

Allis-Chalmers Co., Chicago, Ill.
Aultman Company, Canton, Ohio.
Broderick & Bascom Rope Co., St. Louis, Mo.
Buhl Malleable Co., Detroit, Mich.
H. W. Caldwell & Sons Co., Chicago, Ill.
Case Mfg. Co., Columbus, Ohio.
Dayton Globe Iron Works Co., Dayton, O.
General Electric Co., New York.
Hayward Co., 97 Cedar St., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Keasey Pulley Co., Toledo, O.
A. Leschen & Sons Rope Co., St. Louis, Mo.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Northern Electrical Mfg. Co., Madison, Wis.
Quincy Engine Works, Quincy, Ill.
Robins Conveying Belt Co., 14-22 Park Row, N. Y.
S. Morgan Smith Co., York, Pa.
Sprague Electric Co., 527 W. 34th St., New York.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Presses and Dies.

The Curtis & Curtis Co., Bridgeport, Conn.
Niagara Machine & Tool Works, Buffalo, N. Y.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Pratt & Whitney Co., Hartford, Conn.
Waterbury Farrel Foundry & Machine Co., Waterbury, Conn.
Watson-Stillman Co., 210 E. 43d St., New York.
R. D. Wood & Co., Philadelphia, Pa.

Pressure Regulators—Steam, Water and Air.

Julian D'Este Company, 24 Canal St., Boston, Mass.
Richard Thompson & Co., 126 Liberty St., New York.

Prospecting Drills.

American Diamond Rock Drill Co., 95 Liberty St., New York.
American Well Works, Aurora, Ill.
Davis Calyx Drill Co., 128 Broadway, New York.

Pulleys, Shafting and Hangers.

Allis-Chalmers Co., Chicago, Ill.
American Tool & Machine Co., Boston, Mass.
Aultman Company, Canton, Ohio.
H. W. Caldwell & Sons Co., Chicago, Ill.
Case Mfg. Co., Columbus, Ohio.
Cumberland Steel Co., Cumberland, Md.
Fay & Egan, 212-232 W. Front St., Cincinnati, O.
Frank Machinery Co., Buffalo, N. Y.
Jeffrey Mfg. Co., Columbus, Ohio.
Keasey Pulley Co., Toledo, Ohio.
Niles Tool Works Co., New York, N. Y.
Poole Engineering & Machine Co., Baltimore, Md.
Robins Conveying Belt Co., 14-22 Park Row, N. Y.
Wm. Sellers & Co., Philadelphia, Pa.
S. Morgan Smith Co., York, Pa.

Pulverizers.

F. W. Braun Co., Los Angeles, Cal.
Harron, Rickard & McCone, 21 Fremont St., San Francisco, Cal.
E. H. Stroud & Co., 30-36 La Salle St., Chicago, Ill.

Pumps and Pumping Machinery.

Alberger Condenser Co., 95 Liberty St., New York.
Allis-Chalmers Co., Chicago, Ill.
American Well Works, Aurora, Ill.
Ashcroft Mfg. Co., 85-89 Liberty St., New York.
Bacon Air Lift Co., 92 William St., New York.
Geo. F. Blake Mfg. Co., 114 Liberty St., New York.
Bucyrus Co., So. Milwaukee, Wis.
A. S. Cameron Steam Pump Wks., E. 23d St., N. Y.
Clayton Air Compress. Wks., 114 Liberty St., N. Y.
G. M. Davis Regulator Co., 144 Milwaukee Ave., Chicago, Ill.
The Deane Steam Pump Co. of Holyoke, 116 Liberty St., New York.
Epping-Carpenter Co., Pittsburg, Pa.
Flint & Walling Mfg. Co., Kendallville, Ind
General Power Co., 81-83 Fulton St., New York.
Guild & Garrison, Brooklyn, N. Y.
Hall Steam Pump Co., Pittsburg, Pa.
Harron, Rickard & McCone, 21 Fremont St., San Francisco, Cal.
Hercules Gas Engine Works, 217 Bay St., San Francisco, Cal.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Kingsford Fdy. & Mch. Works, Oswego, N. Y.
Knowles Steam Pump Wks., 114 Liberty St., N. Y.
The Laidlaw-Dunn-Gordon Co., 116 Liberty St., New York
Machinery & Electrical Co., Los Angeles, Cal.
John H. McGowan Co., Cincinnati, Ohio.
Morris Machine Works, Baldwinsville, N. Y.
Pneumatic Eng'g Co., 128 Broadway, N. Y.
Providence Engineering Works, Providence, R. I.
Wm. F. Quimby, 86 Liberty St., New York.
Quincy Engine Works, Quincy, Ill.
Rider-Ericsson Eng. Co., 35 Warren St., New York.
Snow Steam Pump Works, 116 Liberty St., N. Y.
Southwark Foundry & Machine Co., Phila., Pa.
William Tod Company, Youngstown, Ohio.
Watson-Stillman Co., New York City.
Webster, Camp & Lane Machine Co., Cleveland, O.
Robt. Wetherill & Co., Chester, Pa.
Wheeler Condenser & Engineering Co., 120 Liberty St., New York.
R. D. Wood & Co., Philadelphia, Pa.
Henry R. Worthington, 118 Liberty St., New York.
U. S. Wind Engine & Pump Co., Batavia, Ill.

Pump Valves.

Boston Belting Co., Boston, Mass.
Power Specialty Co., 126 Liberty St., New York.

Punches and Dies.

Globe Machine & Stamping Co., Cleveland, Ohio.

Punching and Shearing Machinery.

Bethlehem Foundry & Mch. Co., So. Bethlehem, Pa.
Cleveland Punch & Shear Works, Cleveland, Ohio.
Harron, Rickard & McCone, San Francisco, Cal.
Hilles & Jones Co., Wilmington, Del.
A. Garrison Foundry Co., Pittsburg, Pa.
Morgan Construction Co., Worcester, Mass.
The National Machinery Co., Tiffin, O.
Niagara Machine & Tool Works, Buffalo, N. Y.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Pond Machine Tool Co., Plainfield, N. J.
Pratt & Whitney Co., Hartford, Conn.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Waterbury Farrel Foundry & Machine Co., Waterbury, Conn.
R. D. Wood & Co., Philadelphia, Pa.

For Alphabetical Index to Advertisers see inside back cover.

Quarrying Machinery.
Broderick & Bascom Rope Co., St. Louis, Mo.
A. S. Cameron Steam Pump Wks., E. 23d St., N. Y.
Engineering Works of Wonham-Magor, 29 Broadway, New York.
Cooper, Hewitt & Co., 17 Burling Slip, New York
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Lambert Hoisting Engine Co., Newark, N. J.
A. Leschen & Sons Rope Co., St. Louis, Mo.
Lidgerwood Mfg. Co., New York City.
John H. McGowan Co., Cincinnati, Ohio.
Rand Drill Co., 128 Broadway, New York.
Robins Conveying Belt Co., 14-22 Park Row, N. Y.
Trenton Iron Co., Trenton, N. J.
Vulcan Iron Works Co., Toledo, Ohio.

Radiators.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City, N. J.
John Simmons Co., 110 Centre St., New York.
H. B. Smith Co., 137 Centre St., New York.

Racks—Machine Cut.
R. D. Nuttall Co., Pittsburg, Pa.

Rail Braces.
Atlas Railway Supply Co., Chicago, Ill.
Continuous Rail Joint Co. of Am., Century Bldg., Newark, N. J.
Wonham-Magor Eng'g Wks., 29 B'way, New York.

Rail Joints.
Atlas Railway Supply Co., Chicago, Ill.
Continuous Rail Joint Co. of Am., Century Bldg., Newark, N. J.

Railway Shop Machinery.
Chester B. Albree, Allegheny, Pa.
W. F. & John Barnes Co., Rockford, Ill.
Bickford Drill & Tool Co., Cincinnati, Ohio.
J. A. Fay & Egan Co., 212-232 West Front St., Cincinnati, Ohio.
Hilles & Jones Co., Wilmington, Del.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Norwalk Iron Works, South Norwalk, Conn.
Pedrick & Ayer Co., Philadelphia, Pa.
Pratt & Whitney Co., Hartford, Conn.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.
Watson-Stillman Co., 210 E. 43d St., New York.

Railway Specialties.
Atlas Railway Supply Co., Chicago, Ill.
Continuous Rail Joint Co. of Am., Century Bldg., Newark, N. J.
Engineering Works of Wonham-Magor, 29 Broadway, New York.
C. W. Hunt Co., West New Brighton, N. Y.
Arthur Koppel, 68 Broad St., New York.
Maryland Steel Co., Sparrows Point, Md.
Jefferson Mfg. Co., Lexington, Mass.
John A. Mead Mfg. Co., New York City.
Pennsylvania Steel Co., Steelton, Pa.
H. K. Porter Co., Pittsburg, Pa.
Pratt & Whitney Co., Hartford, Conn.
Sprague Electric Co., 527 W. 34th St., New York.
Star Brass Mfg. Co., Boston, Mass.
Vulcan Iron Works Co., Toledo, Ohio.
Westinghouse Air Brake Co., Pittsburg, Pa.
U. S. Wind Engine & Pump Co., Batavia, Ill.

Reamers.
Standard Tool Co., Cleveland, Ohio.

Refrigerating Machinery—SEE ICE-MAKING MACHINERY.

Retort Coke Oven.
Kloman Co., Pittsburg, Pa.

Rheostats.
The Cutler-Hammer Mfg. Co., Milwaukee, Wis.
Simplex Electric Heating Co., Cambridgeport, Mass.

Riveting Machines.
Chester B. Albree, Allegheny, Pa.
Chicago Pneumatic Tool Co., Chicago, Ill.
Bethlehem Fdy. & Mch. Co., Bethlehem, Pa.
Thos. H. Dallett Co., Philadelphia, Pa.
Hilles & Jones Co., Wilmington, Del.
The National Machinery Co., Tiffin, O.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Pedrick & Ayer Co., Philadelphia, Pa.
Philadelphia Pneumatic Tool Co., Philadelphia, Pa.
Rand Drill Co., 128 Broadway, New York.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Rivet-Making Machinery.
National Machinery Co., Tiffin, O.

Road-Making Machinery.
Aultman Co., Canton, Ohio.
Vulcan Iron Works, Toledo, Ohio.

Rock Breakers.
Allis-Chalmers Co., Chicago, Ill.
Aultman Co., Canton, Ohio.
Harron, Rickard & McCone, San Francisco, Cal.
Robins Conveying Belt Co., 14-22 Park Row, N. Y.
F. L. Smidth & Co., 66 Maiden Lane, New York.
E. H. Stroud & Co., Chicago, Ill.
Sturtevant Mill Co., Boston, Mass.

Roofing.
Garry Iron & Steel Co., Cleveland, Ohio.
Paraffine Paint Co., San Francisco, Cal.
Standard Paint Co., 100 William St., New York

Rolling Mill Machinery.
Diamond Drill & Machine Co., Birdsboro, Pa.
A. Garrison Foundry Co., Pittsburg, Pa.
Kloman Co., Pittsburg, Pa.
Morgan Construction Co., Worcester, Mass.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Poole Engineering & Machine Co., Baltimore, Md.
Quincy Engine Works, Quincy, Ill.
Robt. Wetherill & Co., Chester, Pa.

Rolls, Chill and Sand.
A. Garrison Foundry Co., Pittsburg, Pa.
Cleveland Punch & Shear Works, Cleveland, Ohio.

Roofing Paints and Varnish.
Paraffine Paint Co., San Francisco, Cal.
Standard Paint Co., 100 William St., New York.

Rope Transmission.
Aultman Company, Canton, Ohio.
Broderick & Bascom Rope Co., St. Louis, Mo.
H. W. Caldwell & Sons Co., Chicago, Ill.
Crocker-Wheeler Co., Ampere, N. J.
C. W. Hunt Co., West New Brighton, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
A. Leschen & Sons Rope Co., St. Louis, Mo.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
Providence Engineering Works, Providence, R. I.

Rubber Goods.
Boston Belting Co., Boston, Mass.
Jenkins Bros., 71 John St., New York.

Rubber Washing Machinery.
Turner, Vaughn & Taylor Co., Cuyahoga Falls, O.

Sand Mixers and Sifters.
The S. Obermayer Co., Cincinnati, Ohio.

Sand Pumps.
Card & Weber Machine Co., Denver, Colo.

Saw-Mill Machinery.
Allis-Chalmers Co., Chicago, Ill.
A. F. Bartlett & Co., Saginaw, Mich.
Curtis & Co. Mfg. Co., St. Louis, Mo.
J. A. Fay & Egan Co., 212-232 West Front St., Cincinnati, Ohio.
Harron, Rickard & McCone, 21 Fremont St., San Francisco, Cal.
Jeffrey Mfg. Co., Columbus, Ohio.
Vulcan Iron Works, San Francisco, Cal.

Saws.
Curtis & Co. Mfg. Co., St. Louis, Mo.

Scales and Balances.
Borden & Selleck Co., Chicago, Ill.
Wm. Ainsworth & Sons, Denver, Col.
F. W. Braun & Co., Los Angeles, Cal.

Screens, Mining.
Robert Aitchison Perforated Metal Co., Chicago, Ill.
Allis-Chalmers Co., Chicago, Ill.
Aultman Company, Canton, Ohio.
Henshaw, Bulkley Co., San Francisco, Cal.
Jeffrey Mfg. Co., Columbus, Ohio.
Robins Conveying Belt Co., 14-22 Park Row, N. Y.

Screw Machines.
Brown & Sharpe Mfg. Co., Providence, R. I.
Jones & Lamson Machine Co., Springfield, Vt.
National Acme Mfg. Co., Cleveland, O.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Pratt & Whitney Co., Hartford, Conn.

For Alphabetical Index to Advertisers see inside back cover.

Separators, Steam and Oil.
Allis-Chalmers Co., Chicago, Ill.
American Tool & Machine Co., Boston, Mass.
Austin Separator Co., Detroit, Mich.
John Davis Co., 51-79 Michigan St., Chicago, Ill.
Julian D'Este Company, 24 Canal St., Boston, Mass.
Direct Separator Co., Syracuse, N. Y.
Goubert Mfg. Co., 85 Liberty St., New York.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City.
Harrison Safety Boiler Works, 3138 N. 17th St., Philadelphia, Pa.
Hoppes Mfg. Co., Springfield, O.
Watson & McDaniel Co., Philadelphia, Pa.

Sewer Pipe Presses and Dies (Clay).
Turner, Vaughn & Taylor Co., Cuyahoga Falls, O.

Shafting—SEE PULLEYS.

Shapers.
Frank Machinery Co., Buffalo, N. Y.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Potter & Johnson Machine Co., Pawtucket, R. I.
Pratt & Whitney Co., Hartford, Conn.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
John Steptoe Shaper Co., Cincinnati, O.
Stockbridge Machine Co., Worcester, Mass.

Shears—SEE PUNCHING MACHINERY.

Sheet Metal Work.
Garry Iron & Steel Co., Cleveland, Ohio.
Globe Machine & Stamping Co., Cleveland, Ohio.
Lyon Metallic Mfg. Co., 18 S. Ann St., Chicago, Ill.

Shutters, Steel Rolling.
Kinnear Mfg. Co., Columbus, Ohio.

Skylights and Ventilators.
G. Drouvé & Co., Bridgeport, Conn.
Garry Iron & Steel Co., Cleveland, Ohio.

Special Machinery.
Globe Machine & Stamping Co., Cleveland, Ohio.

Speed Controllers.
Speed Control Co., The Bourse, Philadelphia, Pa.

Spike Machines.
National Machinery Co., Tiffin, Ohio.

Spiral Gears.
R. D. Nuttall Co., Pittsburg, Pa.

Stand Pipes.
Struthers-Wells Co., Warren, Pa.

Steam Engine Indicators.
Star Brass Mfg. Co., Boston, Mass.

Steam-Regulating Appliances.
American Steam Gauge & Valve Co., Boston, Mass.
Ashcroft Mfg. Co., 85-89 Liberty St., New York.
Crane Co., Chicago, Ill.
G. M. Davis Regulator Co., 144 Milwaukee Ave., Chicago, Ill.
Julian D'Este Co., 24 Canal St., Boston, Mass.
F. W. Foster Mfg. Co., Boston, Mass.
Harrison Safety Boiler Works, 3138 N. 17th St., Philadelphia, Pa.
Jenkins Brothers, 71 John St., New York.
Lunkenheimer Co., Cincinnati, Ohio.
Pittsburg Valve, Fdy. & Cons. Co., Pittsburg, Pa.
Power Specialty Co., 126 Liberty St., New York.
John Simmons Co., 110 Centre St., New York.
Tracy Engineering Co., San Francisco, Cal.
Walworth Manufacturing Co., Boston, Mass.
Watson & McDaniel Co., Philadelphia, Pa.
Williams Gauge Co., W. Pittsburg, Pa.

Steam Pile Hammers.
A. F. Bartlett & Co., Saginaw, Mich.

Steam Separators.
Austin Separator Co., Detroit, Mich.
Griffing Iron Co., Jersey City, N. J.
Harrison Safety Boiler Works, 3138 No. Seventeenth St., Philadelphia, Pa.

Steam Shovels.
Bucyrus Co., So. Milwaukee, Wis.
C. W. Hunt Co., West New Brighton, N. Y.
Marion Steam Shovel Co., Marion, Ohio.
Vulcan Iron Works Co., Toledo, Ohio.

Steam Specialties.
Ashcroft Mfg. Co., 85-89 Liberty St., New York.
Ashton Valve Co., Boston, Mass.
Austin Separator Co., Detroit, Mich.
Crane Co., Chicago, Ill.
Eagle Oil & Supply Co., 104 Broad St., Boston, Mass.
G. M. Davis Regulator Co., 144 Milwaukee Ave., Chicago, Ill.
John Davis Co., 51-79 Michigan St., Chicago, Ill.
Julian D'Este Company, 24 Canal St., Boston, Mass.
F. W. Foster Mfg. Co., Boston, Mass.
Foster Engineering Co., Newark, N. J.
Griffing Iron Co., Jersey City, N. J.
Harron, Rickard & McCone, 21 Fremont St., San Francisco, Cal.
Lunkenheimer Co., Cincinnati, Ohio.
McNab & Harlin Mfg. Co., 56-60 John St., N. Y.
Power Specialty Co., 126 Liberty St., New York.
John Simmons Co., 110 Centre St., New York.
Richard Thompson & Co., 126 Liberty St., New York.
Tracy Engineering Co., San Francisco, Cal.
Walworth Mfg. Co., Boston, Mass.
Watson & McDaniel Co., Philadelphia, Pa.
Wright Mfg. Co., Detroit, Mich.

Steam Superheaters.
Power Specialty Co., 126 Liberty St., New York.

Steam Traps.
American Blower Co., Detroit, Mich.
G. M. Davis Regulator Co., 144 Milwaukee Ave., Chicago, Ill.
Julian D'Este Company, 24 Canal St., Boston, Mass.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City, N. J.
John Simmons Co., 110 Centre St., New York.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.
Walworth Manufacturing Co., Boston, Mass.
Watson & McDaniel Co., Philadelphia, Pa.
Wright Mfg. Co., Detroit, Mich.

Steel.
Wm. Jessop & Sons, Ltd., 91 John St., New York.
Kloman Co., Pittsburg, Pa.
Latrobe Steel Co., Philadelphia, Pa.
Maryland Steel Co., Sparrows Point, Md
Pennsylvania Steel Co., Steelton, Pa.
E. M. Shaw, Providence, R. I.
Taylor Iron and Steel Co., High Bridge, N. J.
Walworth Manufacturing Co., Boston, Mass.
Willamette Iron & Steel Wks., Portland, Ore.

Steel Balls.
Federal Mfg. Co., Cleveland, O.

Steel Pipe Flanges.
Latrobe Steel Co., 1200 Girard Bldg., Phila., Pa.

Steel Rings.
Latrobe Steel Co., 1200 Girard Bldg., Phila., Pa.

Steel Shells.
Latrobe Steel Co., 1200 Girard Bldg., Phila., Pa.

Steel Tanks.
L. O. Koven & Bro., 50 Cliff St., New York City.
Lyon Metallic Mfg. Co., 18 S. Ann St., Chicago, Ill.

Steel Tote Boxes.
Lyon Metallic Mfg. Co., 18 S. Ann St., Chicago, Ill.

Stokers—Mechanical.
Babcock & Wilcox Co., 85 Liberty St., New York.
Ross & Co., 95 Liberty St., New York.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Storage Batteries.
Electric Storage Battery Co., Philadelphia, Pa.

Structural Iron Work.
Chester B. Albree, Allegheny, Pa.
American Bridge Co., 100 Broadway, N. Y.
Berlin Construction Co., Berlin, Conn.
Browning Engineering Co., Cleveland, Ohio.
Garry Iron and Steel Co., Cleveland, O.
Riter-Conley Mfg. Co., Pittsburg, Pa.
Wm. B. Scaife & Sons Co., Pittsburg, Pa.

Sugar-House Machinery.
American Tool & Machine Co., Boston, Mass.
Jeffrey Manufacturing Co., Columbus, Ohio.
Link-Belt Eng'g Co., Nicetown, Philadelphia, Pa.
Robins Conveying Belt Co., 14-22 Park Row, N. Y.
R. D. Wood & Co., Philadelphia, Pa.

For Alphabetical Index to Advertisers see inside back cover.

Tanks, Iron.
Allis-Chalmers Co., Chicago, Ill.
Atlantic Works, East Boston, Mass.
Aultman Company, Canton, Ohio.
Flint & Walling Mfg. Co., Kendallville, Md.
L. O. Koven & Brother, 50 Cliff St., New York.
Ritter-Conley Mfg. Co., Pittsburg, Pa.
Wm. B. Scaife & Sons Co., Pittsburg, Pa.
S. Morgan Smith Co., York, Pa.
Struthers-Wells Co., Warren, Pa.
Robt. Wetherill & Co., Chester, Pa.
U. S. Wind Engine & Pump Co., Batavia, Ill.

Tanks.
W. E. Caldwell Co., Louisville, Ky.
Flint & Walling Mfg. Co., Kendallville, Md.
Lacy Mfg. Co., 334 N. Main St., Los Angeles, Cal.
U. S. Wind Engine & Pump Co., Batavia, Ill.

Taps and Dies.
Crane Co., Chicago.
Morse Twist Drill & Mch. Co., New Bedford, Mass.
Standard Tool Co., Cleveland, Ohio.

Tapping and Reaming Machines.
Philadelphia Pneumatic Tool Co., Philadelphia, Pa.
Pratt & Whitney Co., Hartford, Conn.
Stow Flexible Shaft Co., Philadelphia, Pa.

Telephones.
Ericsson Telephone Co., 296 Broadway, New York

Tenoning Machines.
J. A. Fay & Egan Co., 212-232 West Front St., Cincinnati, Ohio.

Thermometers.
Bristol Co., Waterbury, Conn.
Hohmann & Maurer Mfg. Co., Rochester, N. Y.

Time Recorders.
Am. Watchman's Time Detector Co., Cleveland, O.

Tin Plate Mills.
Diamond Drill & Machine Co., Birdsboro, Pa.
E. H. Stroud & Co., Chicago, Ill.

Tire Plates.
Atlas Railway Supply Co., Chicago, Ill.

Tires—Steel.
Latrobe Steel Co., Philadelphia, Pa.

Transmitting Machinery.
Minneapolis Steel & Machinery Co., Minneapolis, Minn.

Traveling Cranes.
Case Mfg. Co., Columbus, Ohio.
Hayden & Derby Mfg. Co., New York.
Hayward Co., 97 Cedar St., New York.
Niles-Bement-Pond Co., 136 Liberty St., New York.
Shaw Electric Crane Co., Muskegon, Mich.

Trucks.
City Forge & Iron Works, Dayton, O.

Tumbling Barrels.
Globe Machine & Stamping Co., Cleveland, Ohio.

Tumbling Mills.
S. Obermayer Co., Cincinnati, Ohio.

Turnbuckles.
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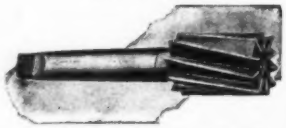

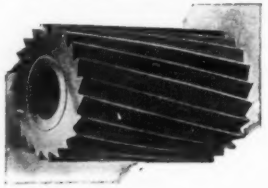

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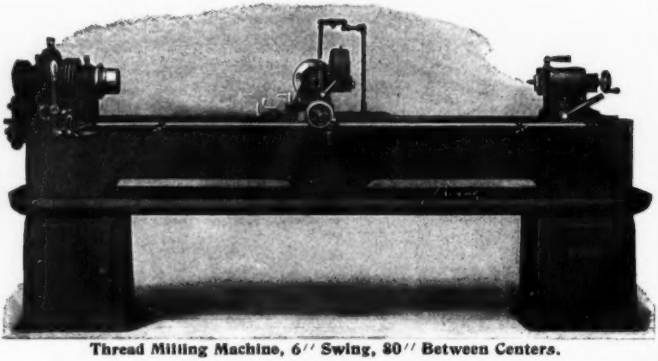

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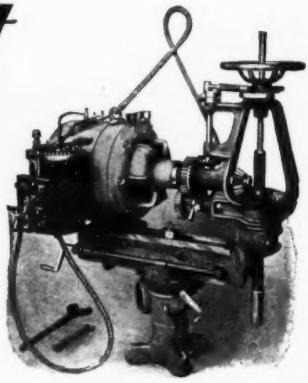

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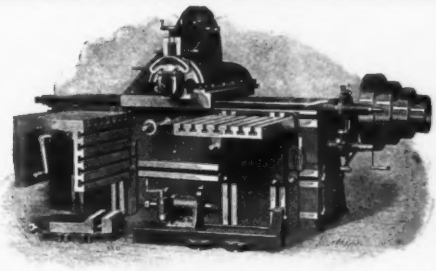

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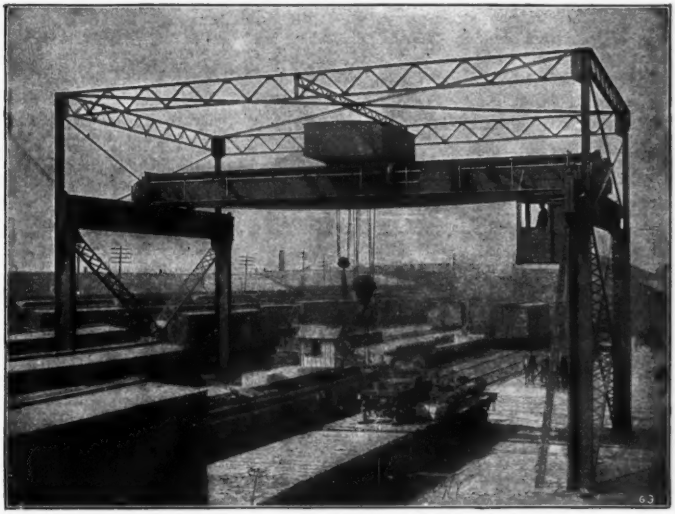

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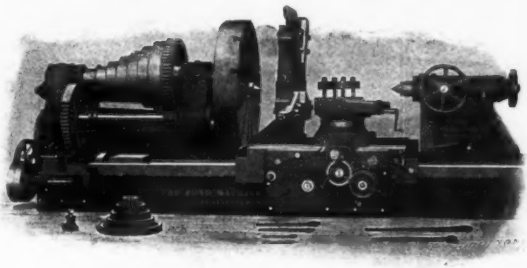

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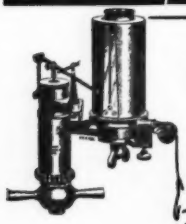

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Edison Portland Cement Works.

THE production of Portland cement in this country has assumed very large proportions within the past few years, and many plants have been built for its manufacture, but it is safe to say that none of them presents so many novel and striking features as the works which have been lately opened at New Village, N. J., for the Edison Portland Cement Company.

It will be remembered that for a number of years Mr. Edison was engaged in perfecting processes and machinery for the utilization of lean iron ores by crushing and magnetic concentration, and the experience gained in this work has now been made use of in the design of the cement plant.

The site selected for the Edison cement works was a practically level tract on the line of the Delaware, Lackawanna and Western railroad, and about 1½ miles from a cement-rock quarry. Here a plant with a capacity of 10,000 barrels of cement a day was laid out in such a manner that it could be built to a fraction of its capacity at first and then enlarged by successive additions to its full projected size.

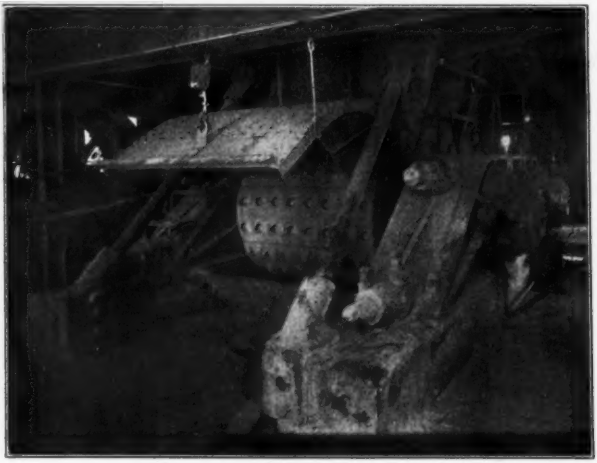
EDISON ROTARY CEMENT KILNS.

The limestone and the cement rock are obtained from different parts of the same quarry, from which the rock is blasted and then loaded, by means of steam shovels, on

to 5-ton steel skips carried on flat cars, and hauled to the works by small locomotives.

At the works the cars are hauled up an incline to the floor of the crusher house, where the skips are dumped by means of a special device comprising a hook which engages with a bail on the skip.

The rock is reduced to the proper size for grinding by passing it through a series of four crushing rolls, located one above another. The first, or top, set of rolls, which receives the rock just as it comes from the quarry, is herewith illustrated and is particularly noteworthy, as it is able to handle pieces of rock up to five tons. These rolls are 5 feet in diameter and 5 feet long, and



GIANT CRUSHING ROLLS, WITH CASING OPEN.

weigh approximately 25 tons each. Their housing is about 18 feet long and 10 feet wide. The wearing or crushing surfaces of the rolls are composed of corrugated segments of chilled iron, and are attached to the body of the rolls by countersunk stud bolts. The rolls are set rigidly and are spaced 8 inches apart.

After passing through these giant rolls, the rock goes in succession through three sets of 36-inch rolls, from the last of which it emerges in sizes of less than one-half inch, and is then carried by a belt conveyor to the dryer, which is a rectangular box, 8 by 8 feet in plan, and 40 feet high, filled with baffle plates, and having an ascending current of hot air from furnaces below.

The dried rock is stored in a stock house having a capacity of 10,500 tons, from which the limestone and the cement rock are delivered by a belt conveyor to the weighing house, there mixed in proper proportions, and then conveyed to a small stock house with a capacity of 1,000 tons.

From the small stock house the mixed rock is taken by a belt conveyor to the grinding house, where it is ground by rolls to a powder, and then conveyed to the blower house, where the fine material is separated from the coarser by an air current. The fine dust is removed from the settling chambers of the blower house by a scraper conveyor and delivered on to a belt conveyor which takes it to the so-called "chalk" store house.

The separated dust is discharged in this store house in a single pile, from which it is taken by a novel device, shown in one of the illustrations and consisting of a screw conveyor of the usual form hung at the bottom of a truss which is pivoted at one end and travels on a track at the other. In operation the truss swings slowly back and forth and the conveyor eats into the deposit of powdered material, and carries it to the hopper at the pivoted end, whence it falls onto a belt conveyor and is distributed by means of a scraper conveyor into the bins of the rotary kilns.

The calcination of the raw material is performed in kilns of the ordinary rotary type, but which have the extraordinary length of 150 feet, and are from 8 to 9 feet in exterior diameter. The two shown in the illustration are the only ones in operation at present, but future extension of the kiln house sufficient to accommodate sixteen more has been provided for. The kiln shells are of cast iron, and are each carried on 15 pairs of wheels, and driven by an elec-

tric motor gearing into a rack encircling the shell.

The fuel used for calcination is powdered coal, which is blown into the kilns by compressed air, after being ground and delivered to the kilns by an elaborate plant.

The clinker from the rotary kilns, after being cooled, is crushed, ground and separated by machinery similar to that employed for the raw material, and is then stored in the cement stock house, which has a capacity of 100,000 barrels. From here the cement is conveyed to the packing house, which is equipped with four

EDISON SCREW CONVEYOR.

bagging machines and two barreling machines.

In the operation of the whole plant human labor has been reduced to a minimum, and conveyors and other mechanical handling apparatus have been employed to an almost unprecedented extent. Much of the machinery is driven by electric motors, while some of the apparatus derives its power direct from steam engines.

Further details concerning this most interesting plant may be obtained from the Edison Portland Cement Co., of New Village, near Stewartsville, N. J.

Warren Rotary Steam Engine.

THE theoretical advantages of the rotary over the reciprocating type of steam engine are well recognized, and there has never been a time in the history of thermo-dynamics when the study of the rotary engine has not engaged the minds of engineers.

The problems, however, involved in the attainment of the object sought have been numerous and their solution peculiarly difficult. Chief among these has been the question of securing steam-tight joints between the moving element and the containing shell or casing, the rate of movement at such joints being necessarily so high as to inhibit any known method of providing a working contact.

To establish and maintain a frictionless steam joint, then, became the principal consideration, and it is in the solution of this primary difficulty that the key to the successful design of the Warren rotary engine is to be found.

This engine consists of a concentric piston wheel and shaft mounted between oppositely placed rotary abutments. The piston wheel carries a broad flange at either end, between which, across the face of the drum of the wheel, the vanes, or, as they may for convenience be termed, the "pistons," are mounted; the outer edge of the blade is turned off in line with the peripheral surface of the flanges, thus adapting these surfaces to run in close contact with the surrounding casing. The main bore of the casing has a slight taper from end to end, and the periphery of the flanges and "pistons" is similarly tapered to fit the bore, and it is by this expedient that the desired condition of continuously maintained "pressureless" contact is established

between the moving flanges and pistons and the surrounding casing. Owing to the slight difference of diameter between the two ends of the tapered wheel, which are exposed to the pressure of steam introduced into the interior of the wheel—the web being perforated in order to establish uniformity of pressure throughout—a moderate end thrust upon the wheel and main shaft is created. the tendency of which is to force the tapered wheel further into the tapered bore, thus closing the joint between flanges, pistons and casing.

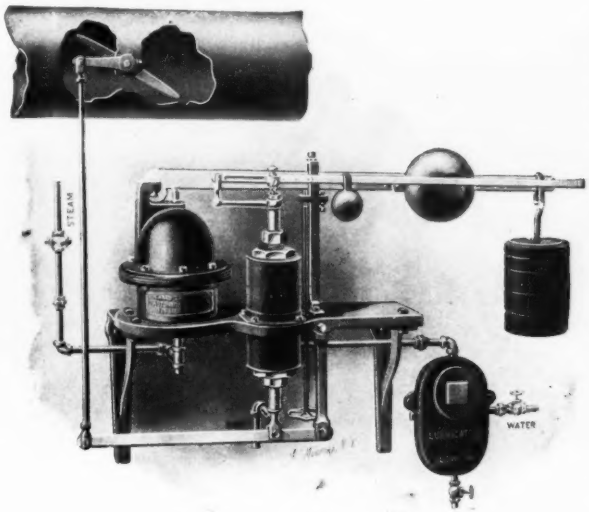
Now, in order to restrain this thrust and secure the desired "grazing" contact between wheel and casing, a small thrust bearing is mounted upon the shaft outside the casing, with provision for adjusting it along the axis of the shaft, thus making it possible to locate definitely the piston wheel in any desired plane relative to the casing. It is obvious that by this means the wheel may be set to run within an infinitesimal distance from the interior surface of the shell, and that through the normal wear on the thrust bearing any deviation from this original plane will be in the direction insuring increasingly intimate contact between the surfaces engaged. It is further evident that, owing to the high peripheral speed of the flanges and pistons which must, necessarily, give rise to rapid wear in case of any pressure existing between the surfaces, and to the fact that the wear upon the well-lubricated thrust bearing under its very moderate load will be exceedingly slow, the resulting end movement on the part of the wheel and shaft will never proceed at a rate sufficient to produce appreciable friction or wear between the involved moving and stationary surfaces. It has been most thoroughly and satisfactorily demonstrated by continuous operation of the engines under service conditions, that the wheel will rotate smoothly at the highest desired speeds, *i. e.*, up to 5,000 feet per minute peripheral speed, while maintained in such intimate contact with the casing that a mirror-like polish is imparted to all the contacting surfaces.

The rotary abutments are connected for rotation with the main wheel through the medium of toothed rings or gears, giving a ratio of two turns of abutment to one of wheel; the single groove in the abutment being thus made to meet successively each piston.

WARREN ROTARY STEAM ENGINE.

Owing to the fact that the respective diameters of drum and abutment do not exactly coincide with the pitch diameters of the gears, a difference of surface speed is established amounting to about 600 feet per minute at normal speed. In this way a sliding contact is created which will cause the two rotating surfaces to wear each other away in harmony with the advance of the abutment due to the normal wear upon its journals. Similarly, the seat formed by the bore of the abutment is worn away at an exceedingly slow rate and thus is established between abutment and wheel and casing, the same condition of ideal

"pressureless" contact described as existing between the main wheel and the casing. By the system described, a practically frictionless joint is secured and maintained automatically and for an indefinite period, the working economy of the engine actually improving through service until a condition of approximate perfection is obtained in all steam joints, after which the economy must remain stationary to the ultimate limit of service. There can therefore be no necessity for adjustment or renewal of parts except through accidents from exterior causes, and necessity for attendance is reduced to the lowest possible point.



THOMPSON AUTOMATIC DAMPER REGULATOR.

Further information concerning this engine and its details will be gladly furnished by the Rotary Engine Company, of Philadelphia.

Damper and Pressure Regulator.

UPON the proper regulation of the draft depends, in a large degree, the economical operation of steam plants, and a great deal of ingenuity has been expended in devising and perfecting apparatus for opening and closing the dampers, so that combustion will proceed evenly and a uniform steam pressure be maintained.

Among the latest and most efficient devices of this class is the Thompson automatic damper regulator, which moves one or more dampers in both directions by means of water pressure, so that they are not necessarily wide open or shut, but may be maintained at any intermediate position. This regulator will close or open the dampers on a variation of one pound of steam pressure, or it will make a partial stroke in either direction and stand at any desired point.

The steam pressure acts on a diaphragm which moves a main lever, connected with a secondary lever, and this latter lever actuates a valve which admits water to a cylinder and discharges it therefrom. The water, which is under pressure, moves a piston that is connected, through levers and rods, or in any other convenient way, to the damper.

On account of the positive application of power in both directions, connections to the dampers can be made by rod direct to the damper lever, bell crank or countershaft, dispensing with chain, pulleys and counterweights, except in some special cases.

One of these regulators will govern from one to twenty boilers, by working as many individual dampers or one or more main dampers.

This device can also be applied to the regulation of the supply and pressure of steam in paper machines and other steam apparatus.

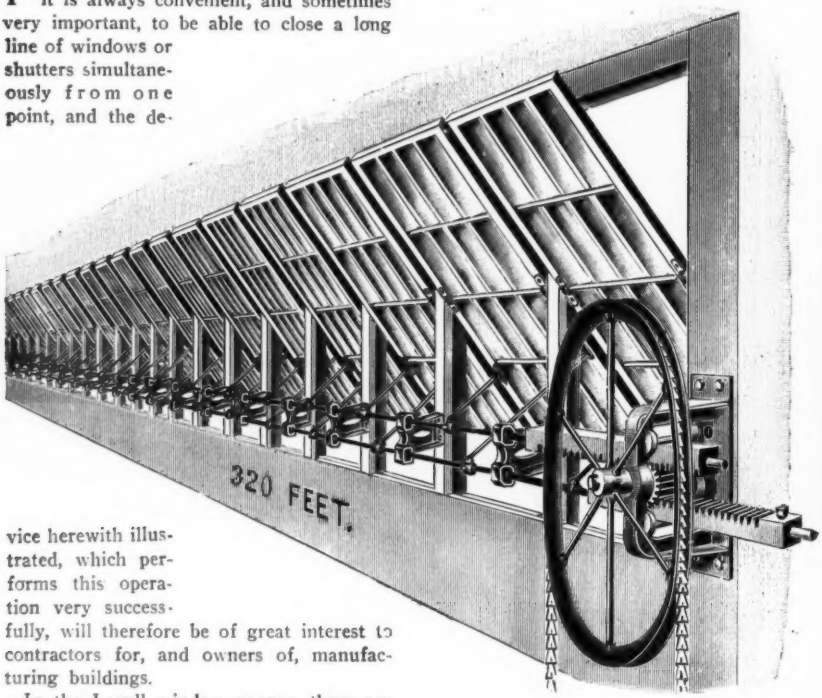
One of the auxiliary features of this regulator is the lubricator and blow-off, through which the water passes on its way to the cylinder. The lubricator is a hollow casting, in which is a cage holding hard soap or lump borax which dissolves slowly

and softens the water, thus lubricating the entrance globe valve and keeping the pipes and passages clear.

The material and workmanship of the whole apparatus are of the very best, and any further information concerning this regulator and their other steam specialties will be gladly furnished by Richard Thompson & Co., 126 Liberty St., New York.

Window and Shutter Operating Device.

IN factories, mills, and similar buildings it is always convenient, and sometimes very important, to be able to close a long line of windows or shutters simultaneously from one point, and the device herewith illustrated, which performs this operation very successfully, will therefore be of great interest to contractors for, and owners of, manufacturing buildings.



LOVELL WINDOW OPENER.

In the Lovell window opener, there are two rods running the length of the line of sash. Two link arms, swiveled at both ends, connect each window with these rods, and as the latter are moved in opposite directions, the arms open or close the sashes by a straight push or pull with no twist.

The rods are supported at numerous points by anti-friction rollers running in adjustable brackets, and at any convenient position on the line there is placed the apparatus for moving the rods back and forth, this apparatus comprising a large wheel, turned by a chain on its circumference and carrying on its shaft a pinion which meshes with rack gears attached to the rods.

A line of sash 500 feet long can thus be operated from one station if desired. As the operating station, unless otherwise ordered, is always placed on the wall at the end or the side of the building, in case of fire the windows can be quickly closed while the people are leaving the factory.

The Lovell window and shutter operating apparatus is strong, durable and practical, and is easily erected. Further information concerning it will be gladly furnished by the manufacturers, The G. Drouve Company, of Bridgeport, Conn.

Water-Softening System.

A RAILWAY water tank, equipped with the Tweeddale patent water-softening system, with a capacity of from 50,000

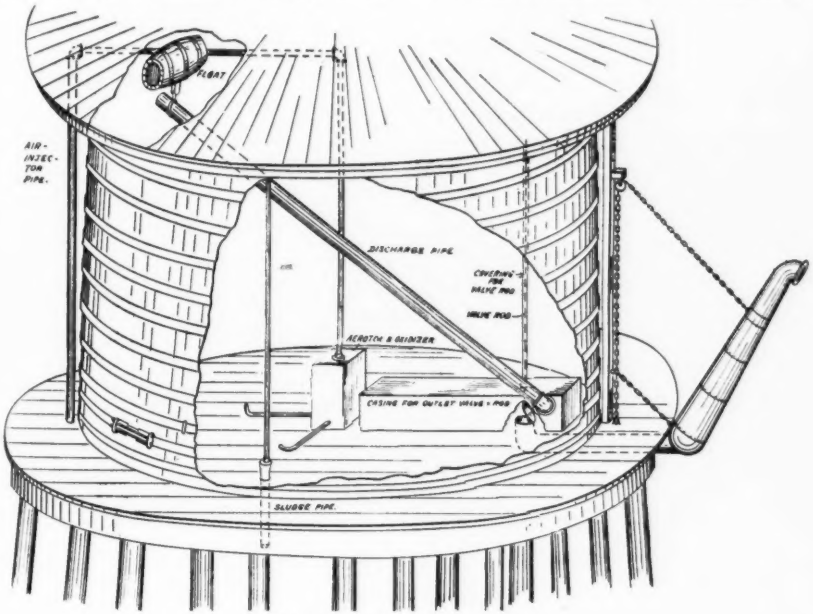
to 60,000 gallons a day, is shown in the accompanying illustration. For larger demands, the treating tank is made independent of the supply tank.

In this water-softening system, there is a casing or box placed over and surrounding the outlet valve that supplies water to the locomotives, the purpose being to entirely separate the water in the tank from the usual means of outlet through the valve. A flexible pipe is attached to the box and has a float fastened to its upper end which always keeps the mouth of the pipe at the surface of the water, so that the supply shall always be clear, soft water until the tank is emptied. The valve rod is enclosed in a pipe extending from the top of the casing to the top of the tank, so that water cannot enter the box by that means, the only way into the box or casing being through the float pipe.

The sediment is all deposited by precipitation on the bottom of the tank, and consists of lime, magnesia, mud, and so on, usually designated as "sludge." This is allowed to accumulate until it is from 8 to 10 inches deep, as its presence in the water, when stirred up each time the water is treated by the compressed air, aids materially the precipitation of solids. When the sediment is deep enough to interfere with operations or if there is danger of any of it getting into the float pipe when the latter is at the bottom of the tank, the excess is partly drawn off through the sludge pipe, some of the sediment being left in the tank.

The compressed air is forced into the aerator and oxidizer located in the center of the tank, by means of a jet air compressor and passes out through the lateral discharge pipes into the water, producing a violent agitation of the latter. Chemicals are introduced into the water in the tank by means of another injector.

In operating the system, the tank is filled, and the air valve is opened, which produces a violent agitation of the water. The proper reagent is then injected and the air current continued for say twenty-five minutes. If necessary, a coagulant is also injected and the air continued for five minutes more. The water can be used in five minutes after the air current is shut



TWEEDDALE RAILWAY-WATER SOFTENER.

off, as the float pipe takes its supply from the surface and the water in the tank will settle faster than it is drawn off. About once a month it will be necessary to draw off the "sludge" down the sludge pipe.

This improvement in water-softening systems, which is applicable to all kinds of industrial establishments as well as to railway supply tanks, was invented by Mr. C. S. Burt, president of the Tweeddale Water Softening Co., of Chicago, from whom further information may be obtained on request.

HISEY PORTABLE RADIAL DRILL.

Portable Electric Radial Drill.

THERE are many advantages in having a tool which can be easily moved about and brought up to its work, and a description of a new machine of this class built on strictly original lines, and known as the Hisey portable electrically driven radial drill, will therefore be of interest.

This drill has a capacity for 1¼-inch holes, and is provided with a 10-inch feed through the hand wheel, with a quick return by hand. It has a radius of 24 inches in any direction and at any angle. The spindle is fitted with a ball-bearing thrust and carries a No. 3 taper socket. It has two speeds, governed by means of a thumb lever on the side, at the lower end of the motor. It is also provided with a switch for starting and stopping, and the machine is under perfect control of the operator at all times.

The vertical and horizontal columns are made of hollow steel tubing. The base is in the form of a letter H, with suitable slots for clamping bolts. The gross weight of this drill is 210 pounds, with a height of 30 inches over all, as illustrated.

It is entirely self-contained and portable in the full sense of the word. It can be taken anywhere, both for inside and outside work, as any desired length of cord can be used. The driving power is derived from any ordinary incandescent lamp socket, with a supply of direct current.

This drill has all the good points of a stationary radial, and, in addition, the great advantage that it can be taken to the work instead of having heavy work brought to it.

This machine is built in its entirety by the Hisey-Wolf Machine Company, of Cincinnati, who will be pleased to give further details on application.

Universal Drafting Machine.

THE T-square and triangle have held sway in the drawing room for so long that, although there are many inconveniences attached to their use, they have been regarded by many as fixed institutions.

But a realization of the loss of time and extra effort which their employment entails has led to the devising of a new apparatus, which is shown in the accompanying illustration.

The machine consists of a graduated square joined to a protractor, and this, in turn, is connected to an arm consisting of two parallelograms, the far end of this arm being fastened to the board, usually at the upper left hand corner. The square by means of this arm has a perfect parallel motion wherever it is moved about the board, and no matter at what angle the square may be set. Spring stops are provided for the angles most commonly used, that is the zero, 30°, 45°, 60° and 90° angles, and by means of these stops the square can readily be set at these angles without waiting to read the protractor.

The scales forming the square merely chuck into place and are readily interchangeable. The chucks are made in the

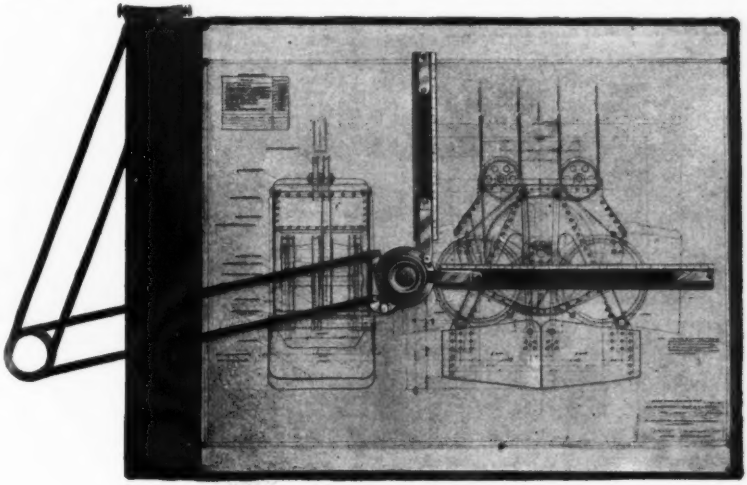
form of a three-point bearing, which insures their always chucking properly, and is one of the improvements recently adopted. Another improvement is an adjustment which allows the square to be lined up to a drawing on which work has already been done.

The joints in the parallelograms are all hardened and ground, thus insuring a very rigid construction. The square moves very easily about the drawing for the reason that the leverage on these joints is very great.

One of the chief time-saving features of this instrument, and much of its convenience are due to the fact that the lines are drawn and measured in one operation, as the scale divisions are right on the square. This saves the constant changing from one edge to another, which is otherwise necessary, and also eliminates a very large amount of the erasing, as the lines are drawn only the desired length. Besides this, all angular work, no matter what the angles may be, is as readily put in as "straight work."

Moreover, the accuracy of this device is not dependent upon the edge of a board, which changes in weather will affect, nor is it dependent upon cords which are bound to stretch.

The Universal Drafting Machine Company, Cleveland, Ohio, the manufacturers of this device, have letters from many persons stating that the saving effected by the use of their instrument will run from 20 per cent. as high as 50 per cent. On strain sheets and such work, the saving is even greater, and the work wore accurate. Further information may be obtained by addressing the above company.



UNIVERSAL DRAFTING MACHINE.

Large Pipe-Cutting Machine.

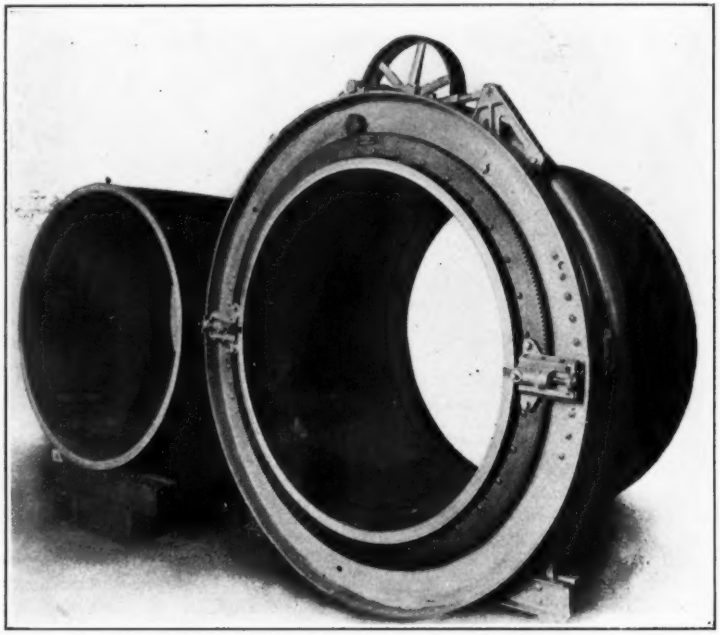
IN the specifications for a contract entered into by the City of Philadelphia in connection with the improvement of its water supply, there was a clause relating to the cutting of large water pipe, part of which read: "Whenever a length of pipe requires cutting to fit in the line, this shall be done with a machine which will leave a smooth end at right angles to the axis of the bore. No cutting with chisel and hammer will be allowed."

To meet this clause, the contractors tried all the machines that were then in the market, without finding any that were satisfactory. Finally, under the direction of Mr. John W. Hill, the chief engineer of the Bureau of Filtration, Department of Public Works, Mr. P. H. Morris undertook the construction of a machine which would fulfil the requirements for cutting a cast-iron

pipe, 60 inches in diameter and 1.7 inches thick.

As shown in the illustration, the frame is formed of two flanged steel heads, having the centre cut out, leaving rings of suitable diameter united by braces, and between which, four jaws, joined by bell cranks and rods, form a readily adjustable gripping chuck.

The cutting tools are attached to a geared ring surrounding a guide ring, bolted to the outside face of one of the heads forming the frame, and revolved by suitable gearing driven by belt or other convenient means.



MORRIS PIPE-CUTTING MACHINE.

The machine is so constructed as to part on the centre line, thus enabling it to be placed in position around the pipe to be cut.

On a shop trial the time occupied in cutting off a 60-inch pipe, 1.7 inches thick, was one hour after adjustment on the pipe, and a trial in practical use in a trench was of an equally satisfactory character to the contractors, who have since reduced the time in actual cutting to forty-eight minutes, and are of the opinion that this time can be still further reduced. They have cut, so far, some ten pipes, and in no instance have they had a break of any character.

There are a number of distinct advantages in a machine of this character for cutting large cast-iron water pipes. The first and most important one is that the pipe cut will be truly at right angles to the axis, leaving a smooth even surface at the end of the pipe, instead of its being more or less angular as when cut with a chisel, and oftentimes so ragged as to make a very poor joint with the adjoining pipe.

The next advantage will be found in economy of time in making a cut, and the economy of pipe. Sixty-inch cast-iron water pipe, such as is being used by the City of Philadelphia on Contract No. 28, Lardner's Point Pipe Distribution System, is worth about $18.67 per lineal foot, and it is very desirable in cutting such pipe to have the

least possible loss. When cutting pipe with a hammer and chisel there is every probability that one, if not both pieces of the pipe may crack in attempting to separate the two pieces by the blows of the hammer. With the pipe cutter described no possible accident can happen to either piece of pipe.

The last, but not the least, advantage, lies in being able to make a closure in a large pipe line with barely enough room between the two pieces to put it in place and allow the usual play for temperature changes in the pipe. With 60-inch pipe it would scarcely be possible with a hammer and chisel to make a closure with a margin less than 1½ inches, while with the improved pipe cutter the margin would not exceed ½ inch.

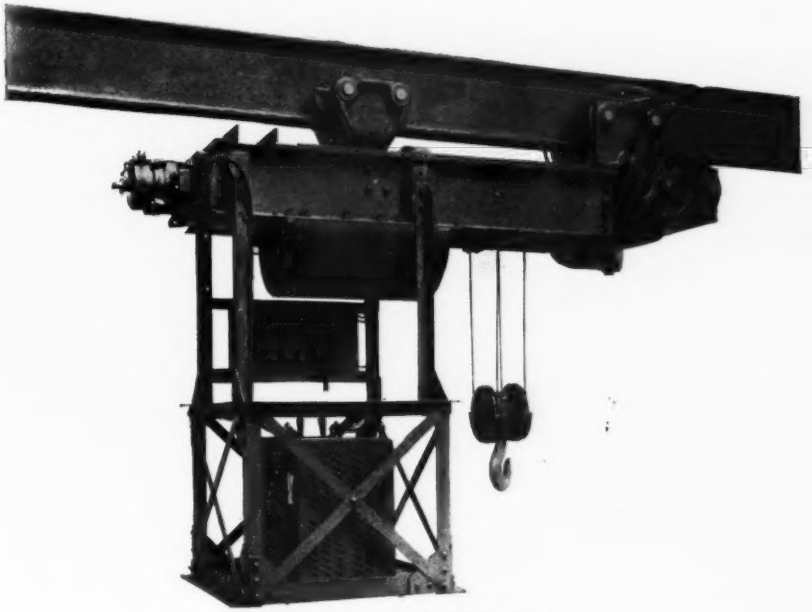
The economy of time is a very important factor. To cut a piece of 60-inch pipe with the best mechanics would certainly require from three to four hours, while with the machine it can readily be done in one hour or less time.

Mr. P. H. Morris, of 1501 S. Front St., Philadelphia, is prepared to furnish estimates for this machine at short notice, of any size that may be required, and will gladly supply any further information upon request.

Niles Electric Traveling Hoist.

HOISTS and cranes are being more and more generally employed for both inside and outside service about shops and works, and the smaller and medium sizes of this class of apparatus have a particularly wide field of usefulness.

One of the latest of these machines is the Niles electric traveling hoist, which is



NILES ELECTRIC TRAVELING HOIST.

shown in the accompanying illustration. These hoists may be equipped with a cage, as illustrated, or may be arranged to be operated from the floor by means of pendant controllers. The hoisting mechanism is placed between the channel framing of the trolley and is direct geared to the drum, a standard load and motor brake being provided. Power for hoisting, in all cases, is furnished by electric motors, while the trolley travel may be arranged for by motor or hand racking.

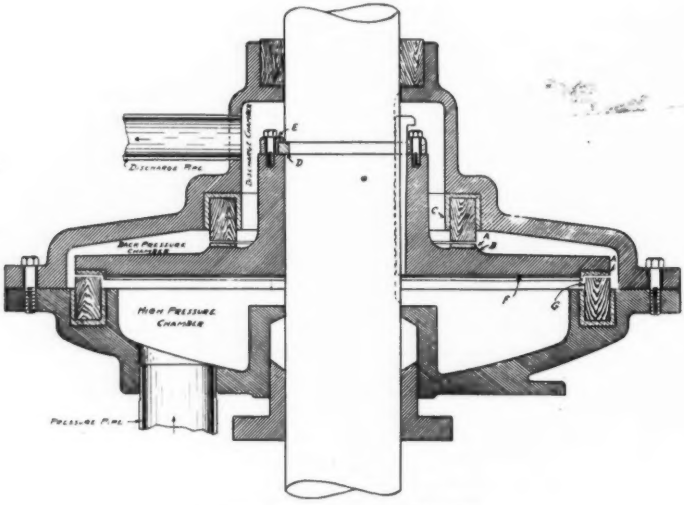
This type of hoist is built in three sizes,

of three, four and ten tons' capacity, and swivel trucks will be furnished for use on curved tracks.

Further information concerning these hoists will be gladly supplied by the manufacturers, the Niles-Bement-Pond Company, of 136 Liberty St., New York.

The Trump Water Thrust Bearing.

THE thrust bearing which is shown in the accompanying illustration is a novelty in its line, being designed not only for taking up the end thrust of vertical and horizontal turbines, but also for carrying the thrust on shafts for other purposes.



TRUMP WATER THRUST BEARING.

The idea of carrying heavy weights on vertical shafts by oil or water pressure is comparatively old. Many devices have been used to enable a heavy weight to be carried with as little friction as possible. Heretofore, however, it has been impossible to carry a variable load automatically; this has been especially the case with turbines carrying heavy loads under high heads. The load on the turbine is always variable, owing to the variation in the gate opening. With the device as shown, the load may vary 100 per cent. and the vertical movement of the shaft will scarcely be noticeable; in other words, it is claimed to take care of the end thrust either on a vertical or horizontal shaft without apparent movement, and, also, to be practically frictionless, the only friction being that caused by a plain disc running in water, without coming in contact with either seat, so that there is no wear.

In the illustration there is shown a disc attached rigidly to the shaft, the disc having two seats with which it never comes in contact. In describing the device two discs are spoken of, one large and one small, but in reality there is only one disc with two faces. The large face has an area 10 per cent. greater than is required to carry the load, so that in practice it is absolutely impossible for it to touch the lignum vitæ seats, and the small disc is usually one-fourth the area of the large one. There is a sheet of water passing constantly between the large face of the disc and the seat into the back-pressure chamber, the raising of the large disc closing the small one enough to allow just back pressure enough to balance the weight to be carried. To put the matter in another way, the large disc has a greater area than is required to carry the load, and the little disc too small an area for this purpose; hence, between the two the load is balanced automatically and instantly with a movement that is scarcely perceptible. The disc is held in place by a

steel ring made in halves, as shown at D. This ring is held in place by a bronze cap E. The seats are preferably of lignum vitæ as shown at G. These lignum vitæ rings are placed in bronze pockets marked C, and can be replaced quickly if necessary. The large disc marked F, and the small disc marked B, are in one piece. The area of the disc is controlled by the diameter of the respective seats. In operation but very little water escapes from the discharge pipe.

Thrust bearings of this kind have been in use over two years, where the large disc is carrying a load of over 70,000 pounds, and up to this time they do not show a variation of over one-sixteenth of an inch. The device is an ideal one to carry the end thrust on propeller shafts for steamships, as the friction is practically nothing, and the pressure is absolutely positive under all variations of thrust. For instance, by taking a disc of 48 inches diameter and using a pressure pump giving a pressure of 300 pounds per square inch, after allowing for the area of a sixteen-inch shaft, a thrust of 482,000 pounds can be carried. A series of these thrust bearings may be installed if necessary. Oil can be used instead of water, although water is preferable, as it is not elastic, and where water is used the variation or end movement is scarcely noticeable.

The above apparatus is fully covered by United States and foreign patents, and is built by the Trump Manufacturing Co., of Springfield, Ohio, from whom further information can be obtained.

Scranton Power Hammer.

THERE is shown in the accompanying illustration an improved upright power hammer, which is designed and built in a manner that should interest all who are required to produce forgings from iron, steel, copper, or other material. The hammer is exceptionally strong in all its parts and simple in all its details. Nothing but iron, steel and brass appears in its construction, with the exception of the leather belt which is employed in the smaller sizes to connect the ram with the ends of the spring, and thereby wood, rubber, and other objectionable materials are eliminated. But little floor space is occupied, and the anvil is separate from the frame, or main casting, extending through the base and resting directly on the foundation, in such a manner as to greatly relieve the jar on the other parts of the hammer, and this, in connection with the leather belt mentioned above, reduces the liability of breakage to a minimum. The ram moves perpendicularly between right and left guides, and has bearings in both front and rear, which insures an absolutely accurate blow. The power is received at the top of the

SCRANTON POWER HAMMER.

hammer and so controlled that the hammer may be started or stopped instantly at the will of the operator. The hammer may be built with the dies to key in from either the front, or side, as may be preferred, and while the design may be changed to meet any special requirements, the regular hammer, as herewith illustrated, has proved entirely satisfactory wherever used on a diversified line of forgings. Special care is exercised in the manufacture of these hammers, and only such material is used in the different parts as has proved most suitable

to withstand the particular strains they receive.

They are manufactured by The Scranton & Co., of New Haven, Conn., who will supply any more information that may be desired.

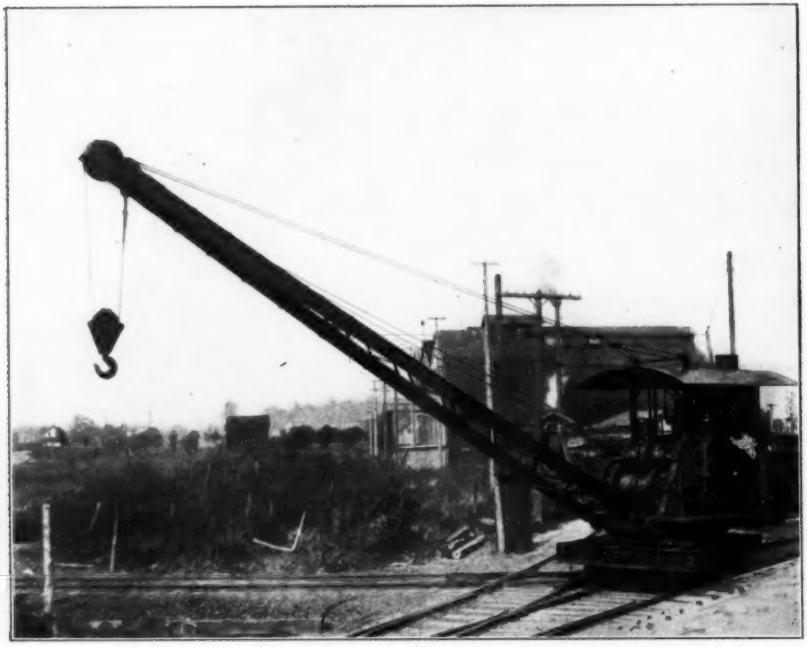
Locomotive Crane.

IN heavy manufacturing lines the decreased cost of production has been due in a large measure to increased speeds of operation of the cranes or other conveying apparatus.

These higher speeds are apt to subject the mechanism of the machines to more severe shock, necessitating heavier construction, or imposing as a penalty shorter life and increased breakage. It is interesting, therefore, to note in connection with this heavier construction, the progress made in the locomotive crane line, as exemplified by the standard locomotive crane built by The Browning Engineering Co.

The elementary features of the machine agree with the accepted practice, the crane consisting of a traveling truck with axles geared, carrying upon its upper surface the rotating base and operating machinery. Worm gears have been entirely eliminated from the rotating mechanism, only bevels and spurs being used, as in the traveling and hoisting functions.

The construction is exceptionally heavy, the operating machinery, including boiler, being carried on the single casting of the rotating base, and the gears being of steel with cut teeth. The arrangement of parts is most convenient for operation as well as for inspection or removal for repair.

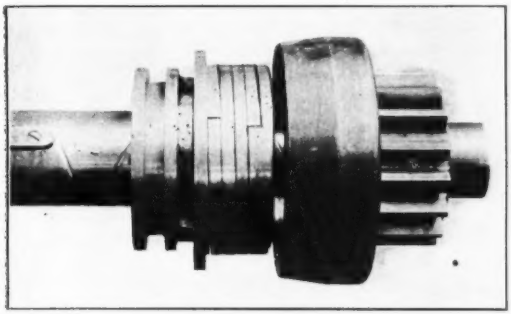


BROWNING LOCOMOTIVE CRANE.

The power is derived from two vertical engines connected at ninety degrees, and the various motions of hoisting, radius varying, rotating and traveling are controlled through clutches. It is in these clutches that a radical departure is made from the customary wooden friction.

The clutch is of a patented type, consisting of a helical spring of self-hardened

steel, which is expanded so as to come into contact with the inner surface of a hardened steel cylinder fastened to the driven gear. The expansion of the spring is accomplished by means of a double wedge, which forces the ends of the spring in opposite directions. The greater the power



BROWNING HELICAL SPRING CLUTCH.

transmitted the greater is the tendency for the clutch to engage, so long as the spring is expanded; hence its drive is very powerful. It is said these clutches have run over a year without adjustment, or even without wearing off the original grinding marks on the spring.

The operating levers are all in one line and are worked from an elevated platform, thus allowing the engineer to have a clear view over the machinery and yet be close to the boiler in a position convenient for firing.

For handling grab buckets the single hoisting drum is replaced by two drums, a patented device inside one drum automatically controlling the opening and closing motions. This eliminates the customary extra clutch with its gearing, and makes the operation entirely automatic and more rapid.

These cranes are built for capacities of from 5 to 60 tons, and more complete information concerning them can be obtained from The Browning Engineering Co., Lock Drawer "Q," Cleveland.

Electrical Resistance Units.

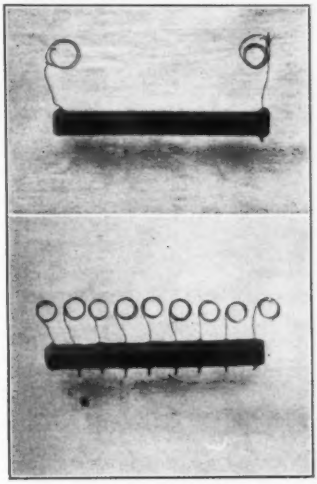
A RESISTANCE unit having 5,000 ohms resistance in a space only 2 inches long by 7/16 inch wide, about the thickness of a lead pencil, has lately been designed and perfected by Mr. H. Ward Leonard.

This unit consists of wire enamelled on a porcelain tube and possesses the following advantageous features:

The resistance wire is imbedded in a material which will expand and contract at the same rate as the resistance itself, within the limits of usage, thus preventing the adjacent coils from closing together and short-circuiting, and preventing, therefore, a change in the resistance of the unit.

The enamel in which the wire is imbedded and by which it is entirely covered, protects it from the atmosphere. As the entire wire is hermetically sealed, it cannot deteriorate from the action of moisture or other corrosive elements.

The coating of enamel over the wire is so thin and the enamel so good a conductor of heat that the heat generated is dissipated very rapidly, the radiation of



WARD-LEONARD RESISTANCES.

heat being accelerated also because the radiating surface is practically increased from that of the fine wire to that of the porcelain tube. The resistance wire has practically a zero temperature coefficient.

The terminals are very strong and the connection between the resistance wire and the terminal head is imbedded in enamel, which preserves the joint against any deterioration. This item is of the greatest importance.

One of the figures shows a high resistance unit tapped to give eight equal steps of resistance.

On a tube 4 inches long by 7/16 inch in diameter, 11,000 ohms can be furnished.

The Ward Leonard Electric Co., of Bronxville, N. Y., will be glad to furnish further information concerning these resistances.

Foster Back-Pressure Valve.

THE type of valve illustrated herewith is an interesting design of back-pressure valve which has been developed especially to meet the demand for a reliable back-pressure regulating device that will not chatter or hammer.

FOSTER BACK-PRESSURE VALVE.

The noiseless operation of this valve is sufficient to recommend its installation, aside from the fact that it is extremely sensitive, and is constructed without weights, direct-acting springs, or loosely fitted wearing parts.

The objectionable hammering and chattering so common to back-pressure valves is entirely overcome in the Foster by the generous proportions of the dash pot which is placed within the valve itself.

The valve casing is formed of two flanged pieces, between which is clamped a plate having radial arms that support a cup-shaped central hub. Over this plate and hub is placed an inverted dish-shaped valve having a dash-pot piston with a guide stem that fits into the cup-shaped center. The valve is held to its seat on the plate, through the action of a spring, by means of a compensating lever.

The impossibility of the valve's chattering practically eliminates wear of the seats, as the valve remains open sufficiently to relieve the excess pressure not being used in the heating mains, and the pulsation of the engine cannot make the valve hammer because of the perfect cushion of the dash pot.

A hand hole is also provided to give ready access to the interior of the valve for the purpose of inspection or repairs without having to disconnect the valve itself from the pipe lines.

When no back pressure is required, a few turns of a screw carries the valve off its seat and throws it out of commission.

These valves are built by the Foster Engineering Co., of Newark, N. J., who will readily furnish any further information that may be desired.

Regulating and Reversing Controllers.

CONTROLLERS for motors used upon cranes and in other places where frequent stops and reversals are necessary must have unusual sturdiness, in order to withstand the strain and wear of constant motion. They must also be simple and positive in action in order to give perfect control of the motor, both in speed and direction of rotation, and with the fewest possible movements of the handle, for with the almost incessant operation of the controller any inconvenience in manipulation would be a serious drawback.

To meet the peculiar requirements of such service, controllers possessing the desired features have been designed. One style of such a device, the commutator type, as made by Westinghouse Electric & Manufacturing Company for use with direct-current series, shunt and compound motors is shown in the accompanying illustration.

For convenience in installation, it is made in two forms. In type No. 178, the controlling mechanism is mounted on the side of the frame containing the resistance, as shown, and in type No. 179 it is mounted above the resistance. The space available for installing controllers for motors used with cranes and other machinery is usually greatly restricted, and this provision for adapting the device to the place in which it is to be used is of corresponding value.

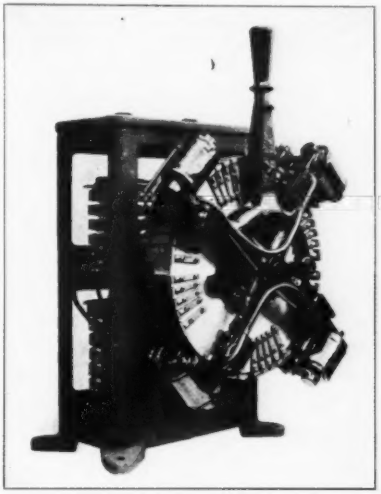
The controlling mechanism is mounted upon a circular slab or base of insulating material, which provides high insulation between adjacent contacts and between the contacts and ground. Throughout the entire controller, ample provision for insulation is made.

Both the contact and finger tips can be easily removed and renewed without disturbing the connections. The contacts are arranged in parallel rows along the periphery of the disc, the relative position of the contacts and the finger tips being the same as that of the brushes and commutator in a generator or motor, a form which has been found more desirable than any other for this particular service. The same contacts are used for application of the current in either direction, thus lessening the number required, while an effective magnetic blow-out makes it impossible to maintain an arc and prevents burning of the contacts.

Each controller has four brush holders mounted upon a rocker arm to which the handle is attached directly, working without gears or pinions. A single movement to right or left applies or reverses the current, and the distance the handle is moved determines the motor speed by varying the amount of resistance in series with the motor armature. There are sixteen steps in each direction and a very close regulation of the speed is thus obtained.

When the controller is placed in the rear of a crane cage, it is operated by a crank and lever directly attached to the spider which carries the brushes. Type No. 179, with the controller mounted above the resistance, is very generally employed for this purpose.

The resistance used with controllers of large capacity is of the grid type, a form the desirability and simplicity of which are universally conceded. For small capacities with large ohmic resistance an improved cell resistance is employed with ventilating spaces between the cells, which are separated by non-combustible insulating spreading blocks. This form provides excellent ventilation, insulation and durability. The resistance is varied for the different capacities and uses of the motor which the controller governs, a different resistance being used for crane controllers, where a close regulation is required, than is provided for



WESTINGHOUSE REGULATING AND REVERSING CONTROLLER.

roll tables and soaking pits where sudden and repeated starting and reversing is the prime requisite.

The chief characteristics of this type of controller are its simplicity, strength, durability, flexibility of application, and ease of manipulation. Any mechanic can care for it, and keep it in order, the cleaning, oiling and renewal of contacts when necessary, being all that is required. All parts are exposed to view, and connections are easily made.

Controllers of the commutator type are made regularly in capacities from ten to seventy-five horse power, and can be furnished especially of any capacity desired. Further information will be gladly furnished by the Westinghouse Electric & Mfg. Co., Pittsburg.

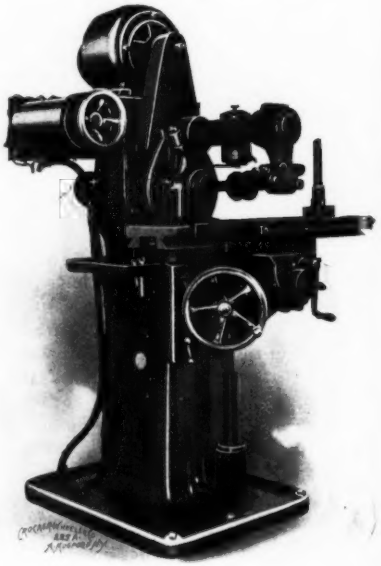
Milling Machines with Motor Drive.

TWO of the latest and neatest schemes for providing milling machines with contained electric-motor drive are illustrated in the cuts herewith. One represents the Cincinnati Milling Machine Company's No. 3 geared-feed miller, and the other is built by the Brown & Sharpe Manufacturing Company, corresponding very closely with its No. 1 universal milling machine. In each instance power is supplied by a Crocker-Wheeler semi-enclosed, shunt-wound motor, and the speed regulation is afforded by a Crocker-Wheeler 12-point controller designed to operate on a 4-wire multiple-voltage system of current supply, giving six speeds by voltages ranging from 40 to 240 by increments of 40 volts each. An equal number of intermediate speeds is secured by the use of resistance, giving in all twelve speeds in either direction.

The location of the motor directly over the machine is the most desirable one possible, as it allows the drive of the spindle to be applied to best advantage, that is, between the bearings, without increasing the floor space occupied by the machine. Another advantage is the use of a Morse rocker-joint chain instead of a belt, the short distance between the centers of the motor shaft and tool spindle making a belt connection almost prohibitive on account of the excessive tension required producing needless waste of power in friction. In its operation the chain is noiseless and positive, and the pull exerted between the shaft and spindle is only that necessary to transmit the power required. The sprockets and chain are entirely enclosed in a light removable cast-iron casing which protects the moving parts from chips and dirt, prevents the throwing of oil at high speeds and removes the menace of torn fingers for the operator.

The Brown & Sharpe machine was designed especially for light rapid work such as the finishing of small brass parts, and requires a motor of only 3 horse power. The table has a 20-inch automatic longitudinal feed and a 6-inch transverse movement, and may be lowered 18 inches from the center of the spindle. The speed reduction from motor to tool is about 3½ to 1, the lowest speed of the motor rotating the spindle at 44 revolutions per minute and the highest speed at 276. To permit the extreme limits of the table travel, the machine requires a floor space 86 inches wide by 44 inches in line with the spindle and an over-all height of motor and machine of but 6 feet 4 inches, so that the motor is readily accessible for inspection or adjustment.

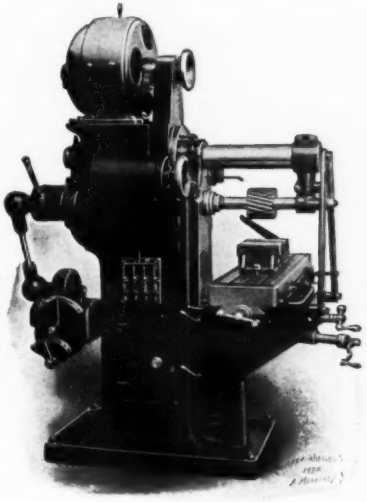
The Cincinnati miller, being built for taking rather heavy cuts in iron, is of substantial proportions and is driven by a 7½-horse-power motor. It is provided with a powerful and positive feed-changing mechanism covering an exceptionally wide range, the gear combination of which may be instantly changed without stopping the machine, regardless of how fast the spindle is turning or how heavy a cut is being taken. There are sixteen of these rates of feed, all of which are plainly indicated by raised figures immediately over the feed lever. The table has a 34-inch automatic longitudinal movement and a 9-inch cross and a 20-inch vertical hand operated movement. Besides the twelve different speeds afforded by the motor when driving the spindle direct, twenty-four more may be secured through



BROWN & SHARPE MILLING MACHINE WITH CROCKER-WHEELER MOTOR DRIVE.

the use of two back-gear combinations. There is a 4-to-1 reduction of speed with the direct drive, while with the back gear in action a 12-to-1 or 28-to-1 reduction is available. The highest possible speed of the spindle is 278 revolutions per minute and the lowest 14.

The height of the machine from the floor to the top of the motor is 85 inches and the floor space required is 77 inches, back to front, and 106 inches, left to right, to allow the full extent of the longitudinal feed. The hand wheel shown on the extension of the motor shaft beyond the chain casing is provided in order that, with the current cut off, the motor may be rotated by hand sufficiently to permit the teeth to intermesh when changing the back-gear combinations. It will be noticed that the web of the wheel is made solid to eliminate any chance of catching the fingers of any one working about the motor when it is running. This same element of precaution to protect the



CINCINNATI MILLER AND CROCKER-WHEELER MOTOR.

workmen will be recognized as an excellent feature that is extended to the entire machine, all gears and dangerous moving parts being carefully enclosed.

Further information concerning these machines will be gladly furnished by the Crocker-Wheeler Co., of Ampere, N. J.

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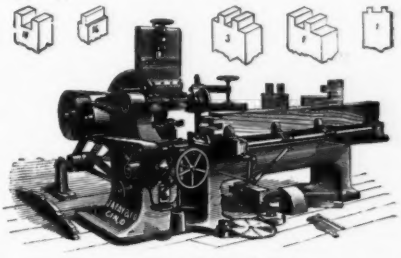
ONE of the most powerful tenoning machines ever built is here represented, and owing to its high quality and range of work, and the large amount it will do, it is placed on the market with the firm belief that it is one of the best machines ever brought out for the use of car builders, and where heavy and general work is desired.



FAY-EGAN TENONER.

Here are a few reasons why this machine should prove successful:

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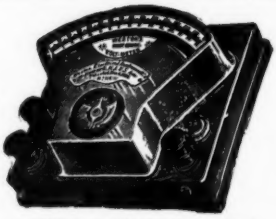

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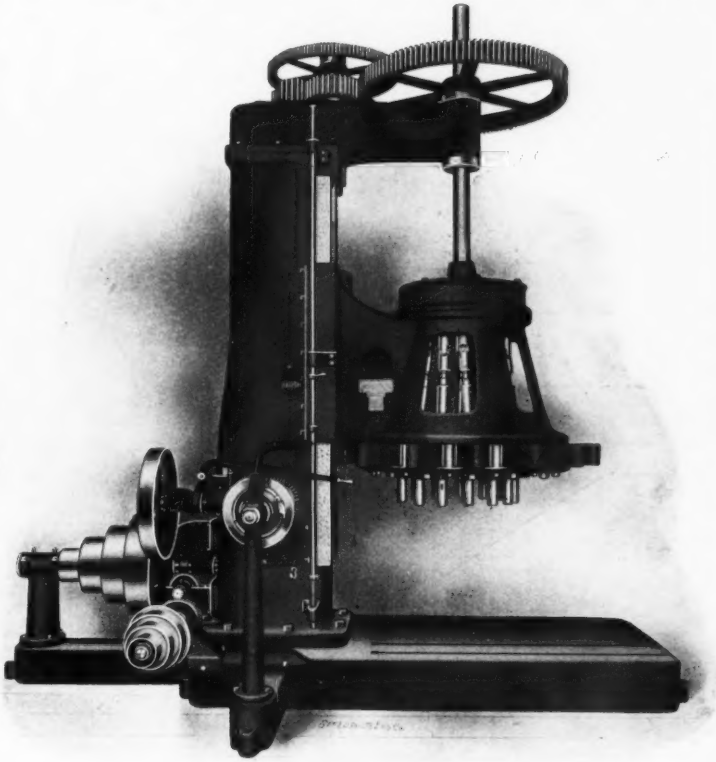

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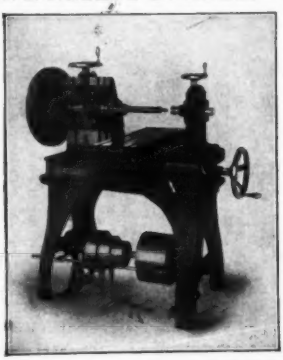

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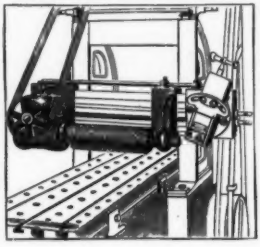

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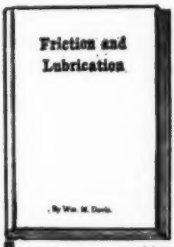

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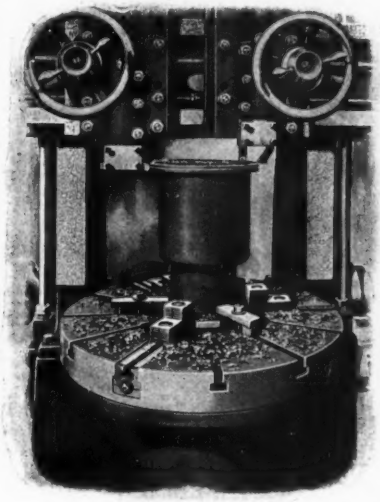

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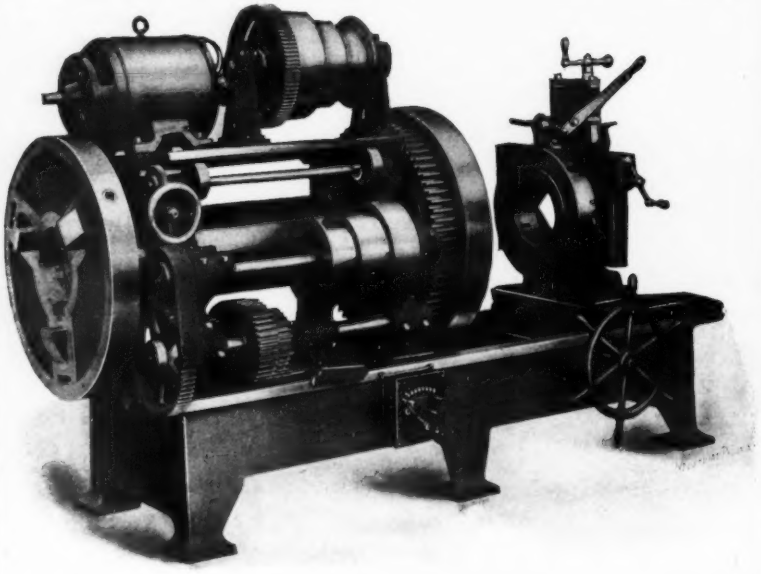

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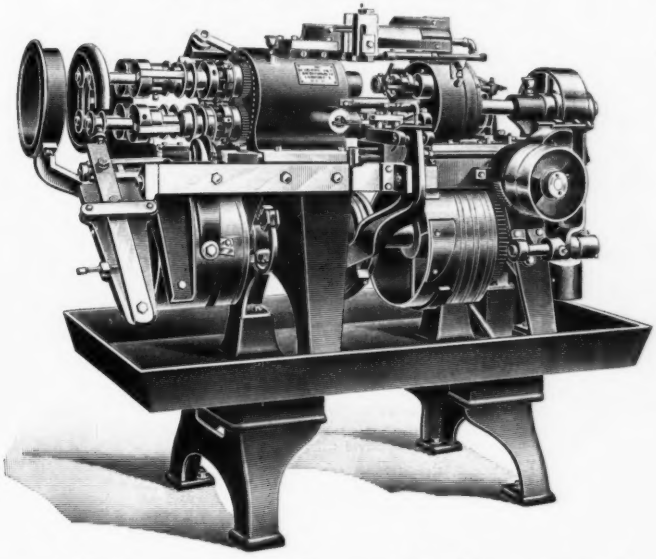

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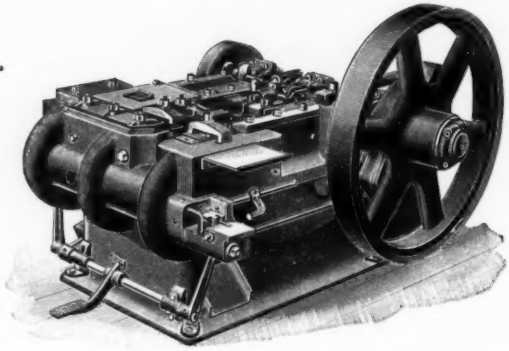

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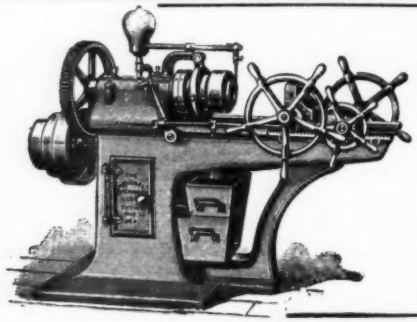

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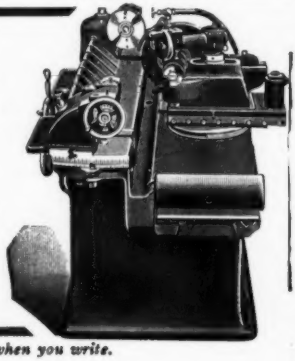

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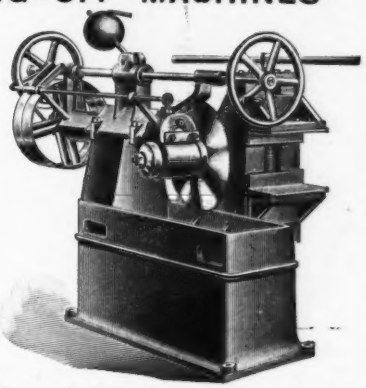

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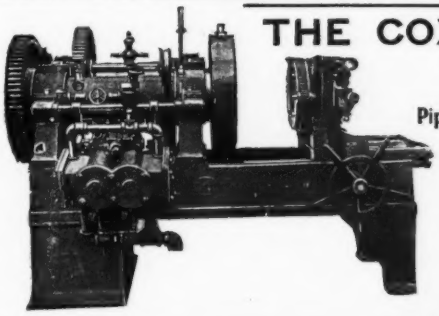

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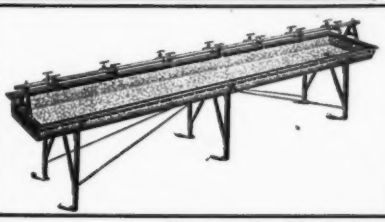

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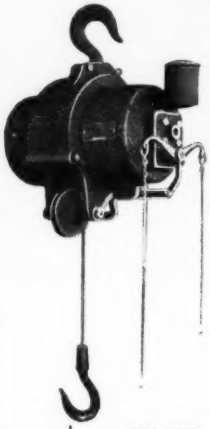

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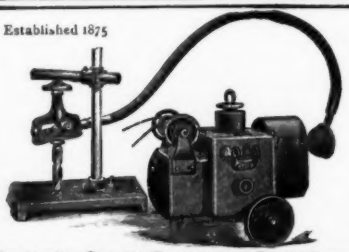

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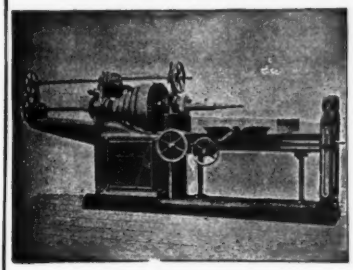

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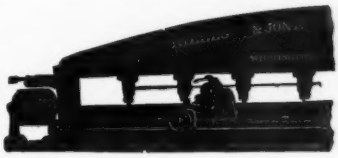

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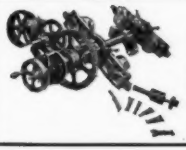

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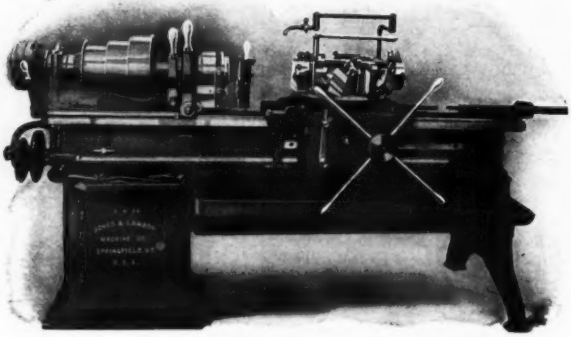

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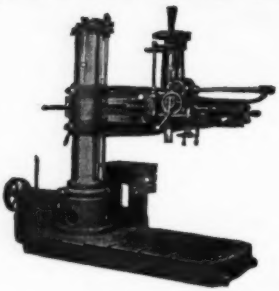

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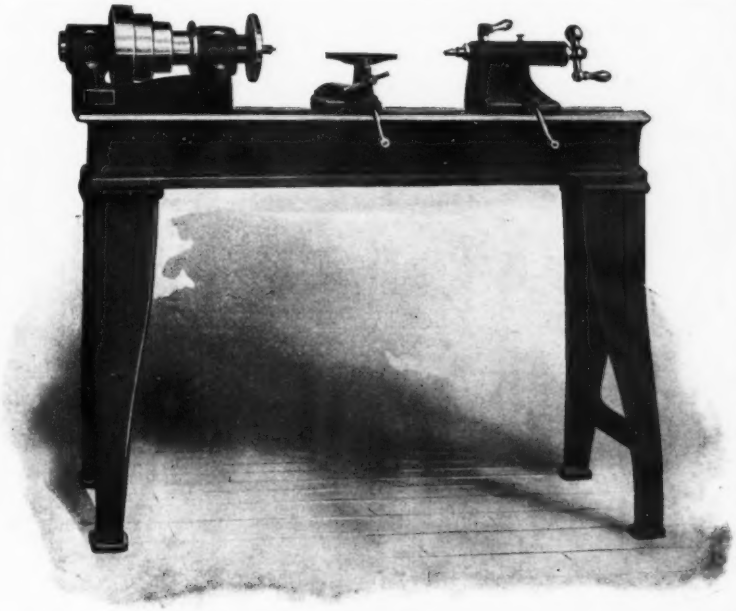

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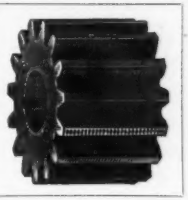

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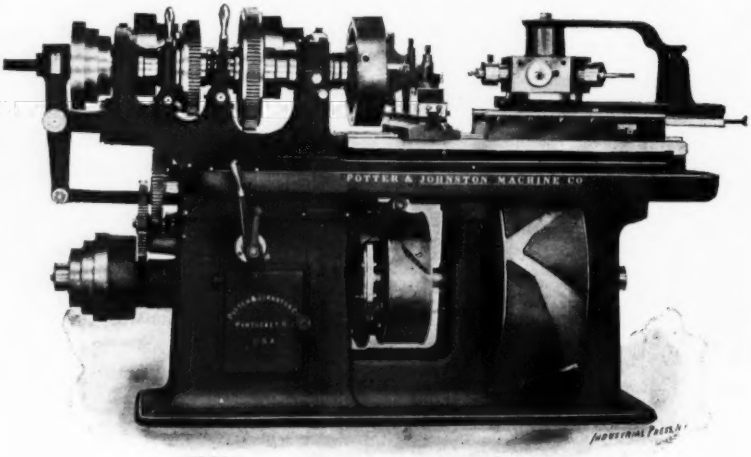

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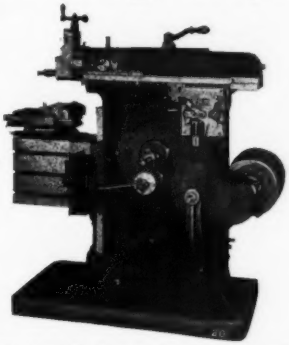

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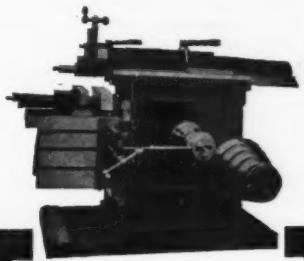

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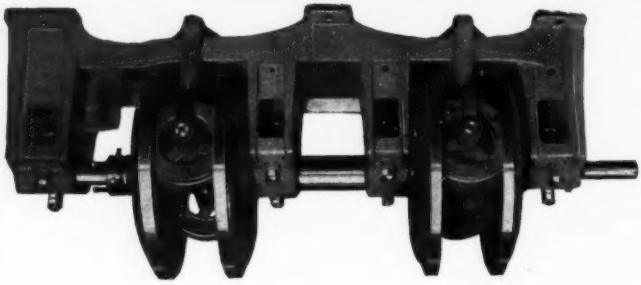

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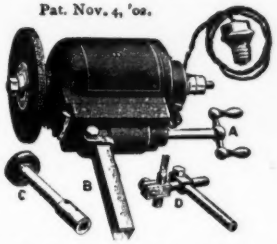

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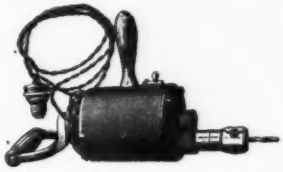

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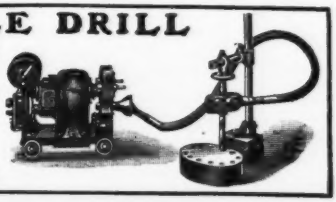

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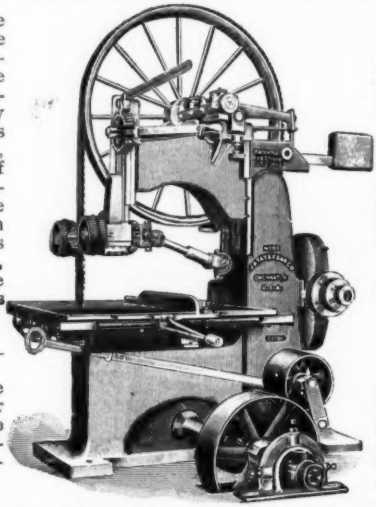

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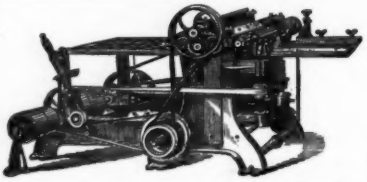

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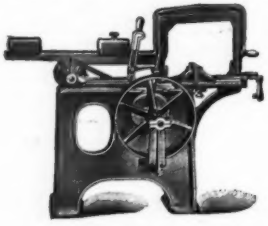

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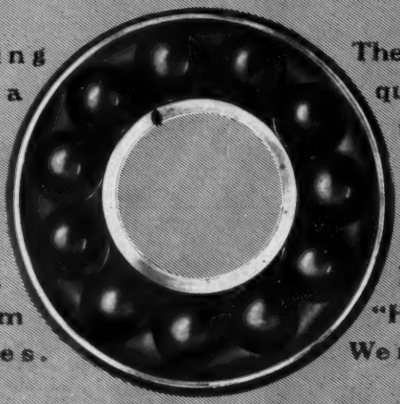

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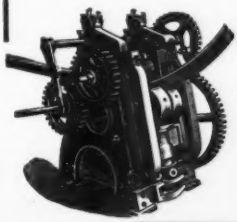

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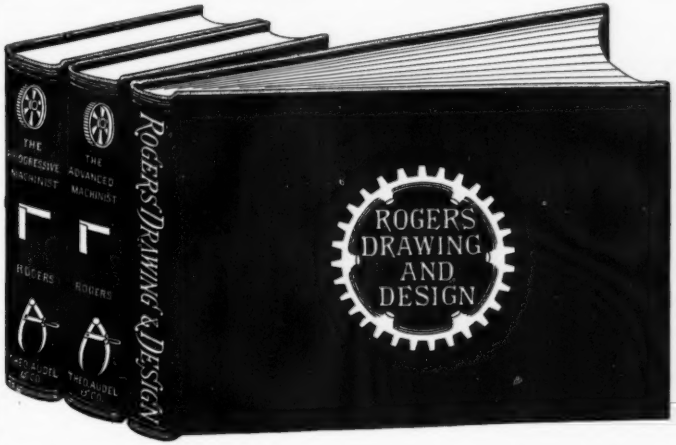

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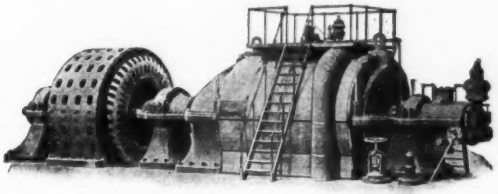

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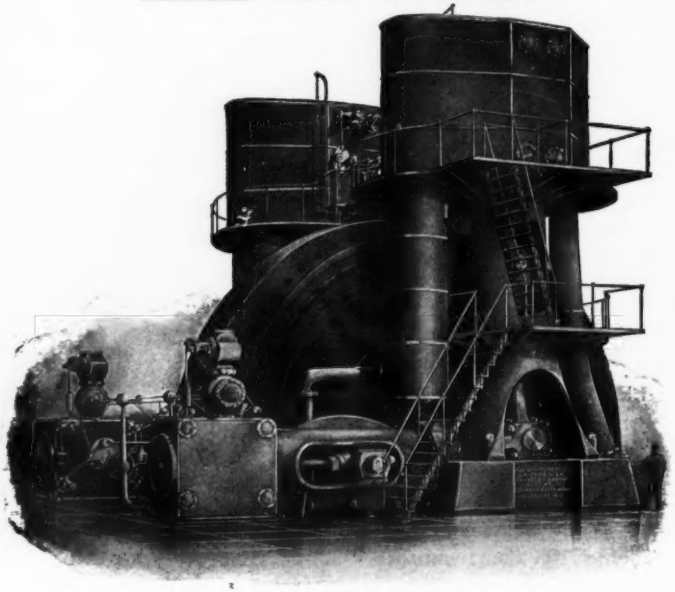

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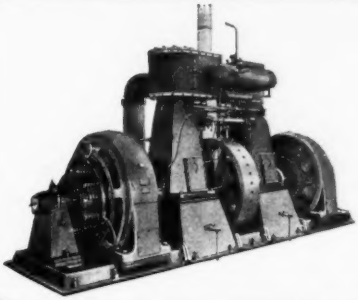

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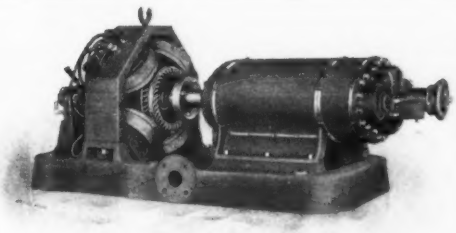

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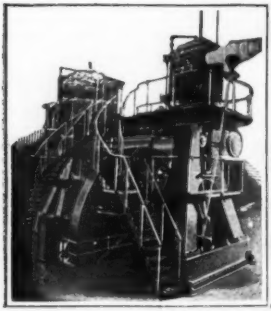

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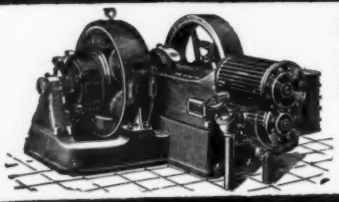

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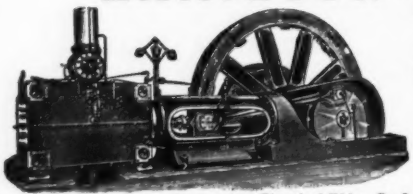

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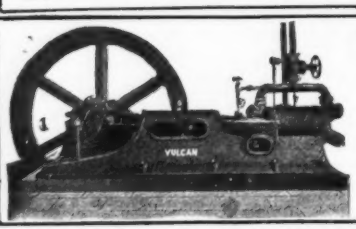

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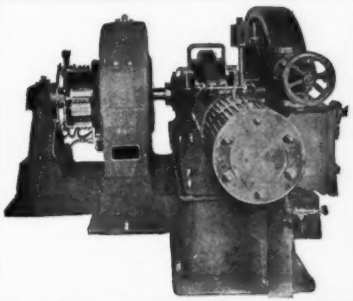

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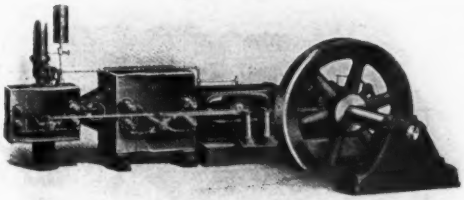

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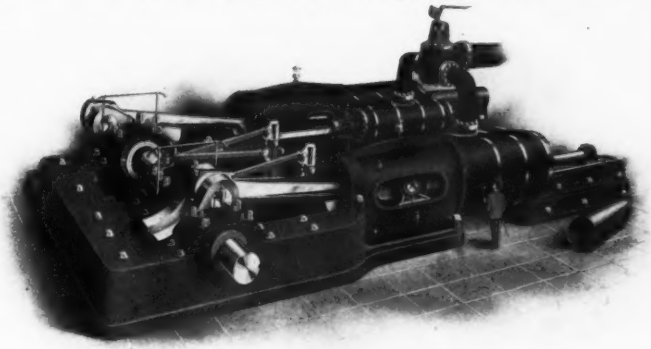

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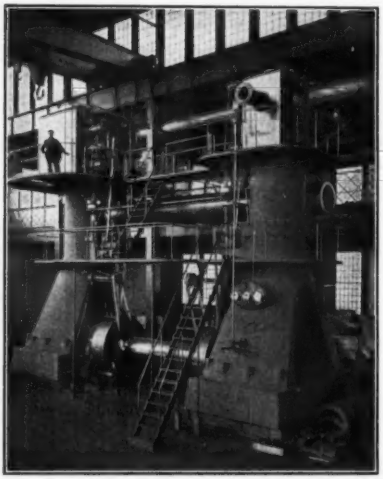

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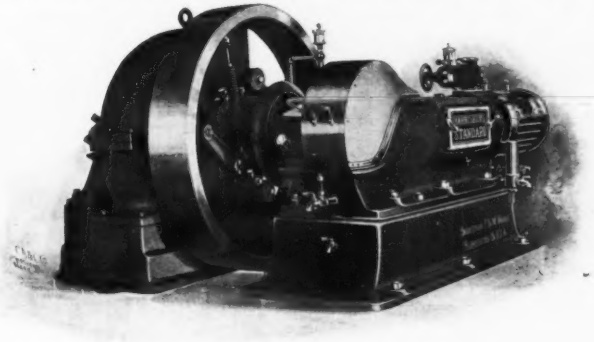

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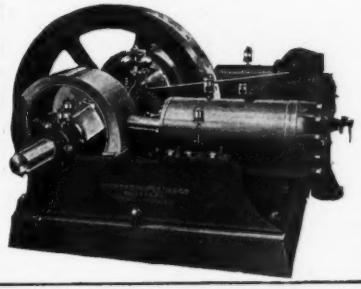

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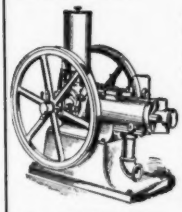

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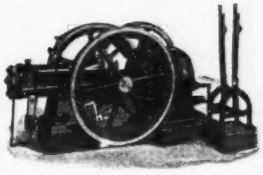

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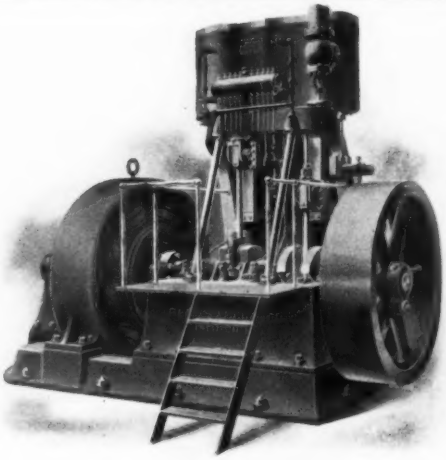

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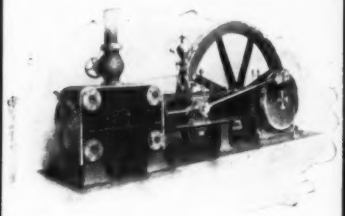

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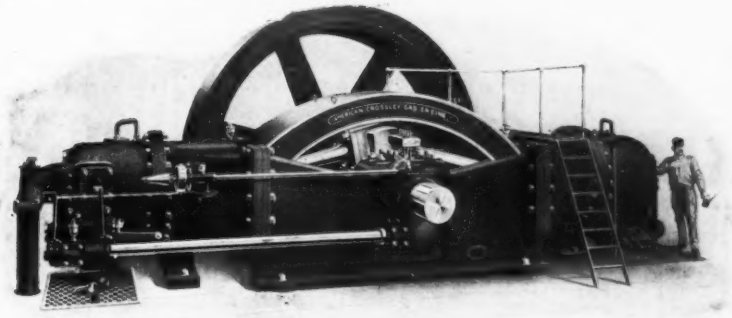

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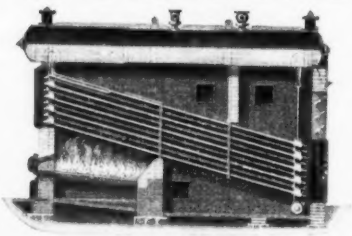

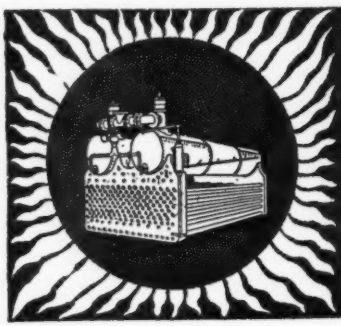

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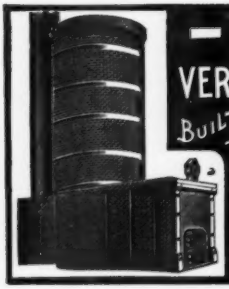

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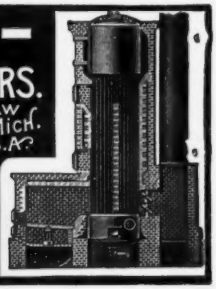

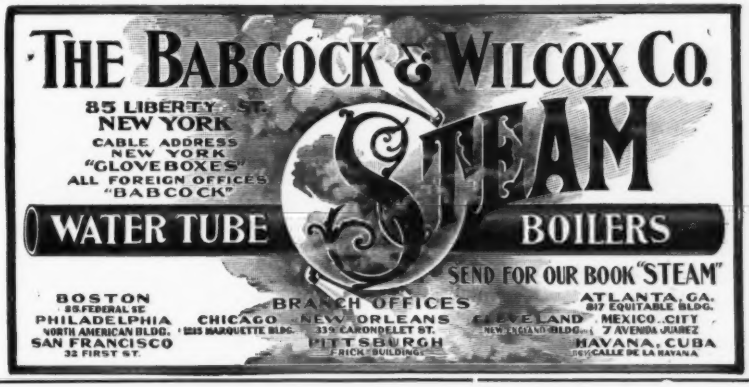

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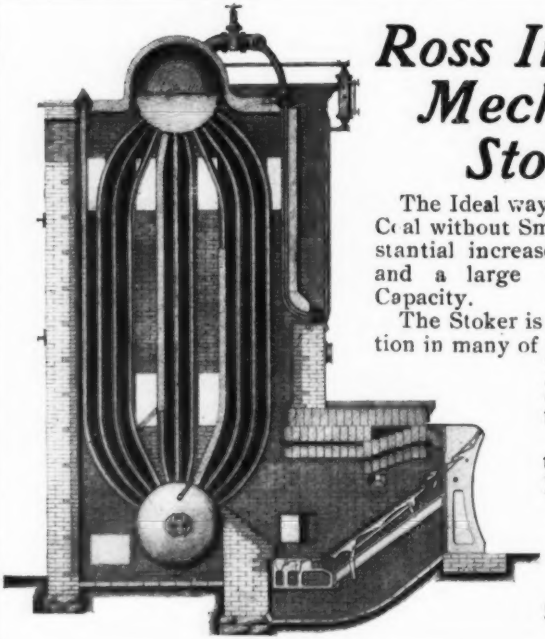

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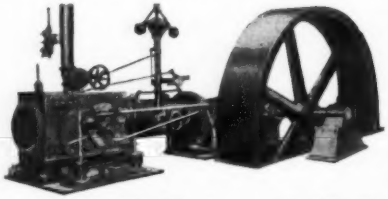

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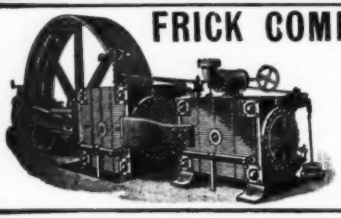

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Write To-Day For Our Booklet "Economy In The Boiler Room"

It's valuable because it tells how to save hundreds of dollars every year in addition to describing the Dean Boiler Tube Cleaner.

For Water Tube Boilers

For Return Tubular Boilers

Boiler scale eats up hundreds of dollars in fuel every year and it can only be removed by means of the

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To prove this we'll loan you a cleaner (free of all cost and without placing you under any obligations to buy) for a thorough trial in your own boiler.

We guarantee this cleaner to at least pay for itself in 6 months' use.

Over 5,000 in successful use now. Don't delay but write to-day.

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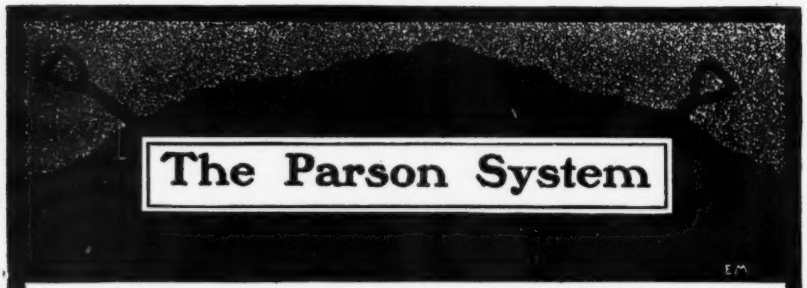

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THE building of boiler furnaces is our specialty. We have been at it thirty years.

We have enabled very many of our customers to save **$1.00 a ton** on their coal.

We enable **All** our customers to use the cheapest fuel procurable and vary their fuel at will.

Boilers equipped with the PARSON SYSTEM readily produce rated horse power or over with the cheapest fuel.

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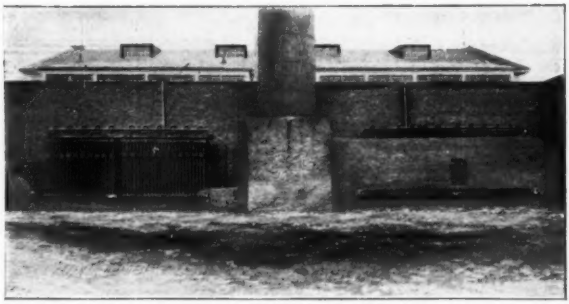

Should be, from the view-point of economy, one of the first considerations, when designing new steam plants or re-modeling the old. Saves from 10 to 20% on fuel supply—heats entire plant without additional cost. Cut shows Economizer in course of erection.

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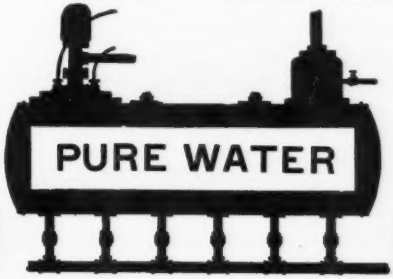

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IS the most perfect device in the world for purifying water for drinking and manufacturing purposes.

It removes all impurities from water.

Fit a Clark Electric Water Purifier with copper tubes and you have a feed-water heater which can purify sea water for use in boilers on ocean and river steamers.

By this method ice can be made much cheaper, because the same results can be obtained WITHOUT evaporation.

No scaling of boilers by its use, thereby saving considerable expense for fuel and prolonging the life of boilers.

We guarantee our system to be as represented or money refunded.

Plants installed on short notice.

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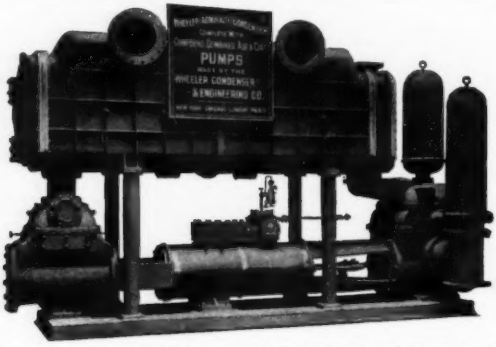

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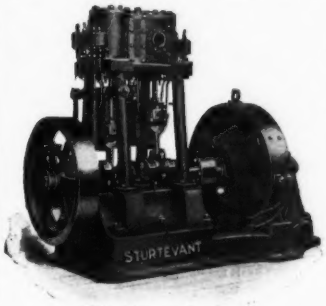

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No chimney required, but may be applied to old plants in connection with a chimney.

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3

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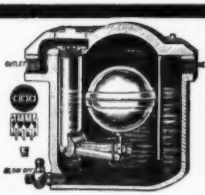
There are three outlet valves in the

WRIGHT "EMERGENCY" HIGH-PRESSURE STEAM TRAP



One valve for ordinary amounts of condensation. Two more valves in reserve for emergencies. All three help to make a wasteless trap of wonderful capacity. Ask for catalog.

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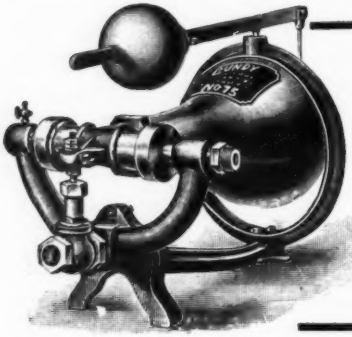

THE SALE OF BUNDY STEAM TRAPS IS UNPRECEDENTED. EVERYBODY SEEMS TO BE ORDERING THEM

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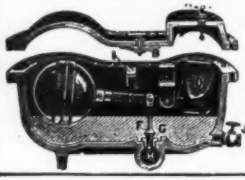

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DISCHARGES CONTINUOUSLY AND NEVER BLOWS STEAM.
MADE EXTRA HEAVY FOR HIGH PRESSURE.

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Return Steam Trap

will automatically return condensed water (at any temperature) to the boiler without loss of heat.

Complete Plant Installations

MINING PUMPING
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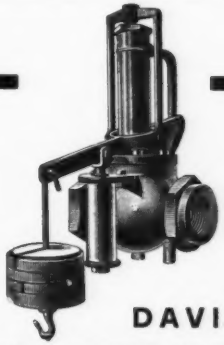

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Simple, Cheap, Reliable

Full amount of heating surface in every heater.
Supplies Water to the Boiler at 212° Fahr.

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Horse Power
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You Have Seen Austin Separators Advertised for Years--

STILL, THERE ARE NEW AUSTIN SEPARATORS.

NEW patterns designed to meet new conditions — Separators that are products of the times —the kind your plant requires.

The work that Austin Separators are built to do, is this—

To Eliminate Moisture from Live Steam; and

To Extract Oil and Other Impurities from Exhaust.

Fig. H, Vertical

To do this work, we provide many different types of separators to suit varied conditions.

A few remedies, no matter how good, will not cure every ailment.

And likewise, in these progressive days, two patterns of separators will not cover all the various requirements met with in different plants.

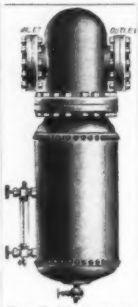

Fig. L, Horizontal

Right here is the advantage of buying an Austin Separator—from our complete line you can get a separator that will meet your particular requirements in every detail. The separator that will save you the most money in operation.

Mail us your requirements and conditions, and we will quote you. Send for catalogue.

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The Eclipse Separator

is so built that the condensation or oil after being separated from the steam does not come in contact with the separated steam. See sectional view. The condensation after separation passes through the pipe into lower chamber and dry steam passes around and out.

Tests made by one of the largest colleges show less than 1 per cent. of moisture in steam after passing through the separator.

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All Separators have their merits. But the

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is *the only one* that will take care of a large influx of water, positively separate it from the steam, and keep it separated, and so long as the drain pipe is open no water will be again picked up and carried to the engine. That involves considerably larger proportions and higher first cost. But it is a wise investment — you get your money back over and over again.

"Dry Steam" is the title of our new pamphlet —written by a distinguished engineer—worth money to every intelligent reader. Free to all parts of the world on request.

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REDUCE YOUR COAL BILLS!

By Putting your water in the Boiler at Boiling Point.

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Tubular Feed Water Heater and Purifier,

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Guaranteed to heat the feed water to the **Boiling Point** (210° or 212°) with the exhaust steam without causing any back pressure. Also to **Extract the Oil** from the exhaust so that the exhaust steam, after being passed through the heater, can be used for heating purposes and the water of condensation from the heating system be returned to the boilers without the extra expense of an additional oil separator or eliminator.

WE GUARANTEE THIS HEATER WILL NOT GET FOUL WITH SEDIMENT.

A LIBERAL OFFER. Try us! If this heater fails to give satisfaction in every respect we will pay freight, cartage and all expenses.

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WEBSTER FEED-WATER HEATERS AND PURIFIERS,

not being "thoroughfare" heaters, are safe from such accidents. Then, as they use only just enough steam to heat the feed-water to the boiling point, they are unequalled for economy. Write for booklet.

Warren Webster & Co.

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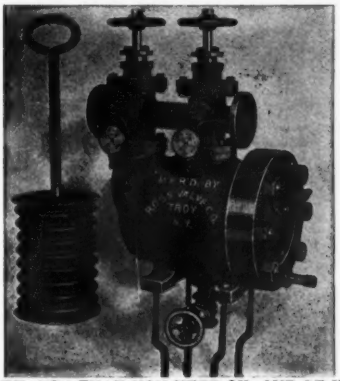

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FOR MARINE OR LAND SERVICE.

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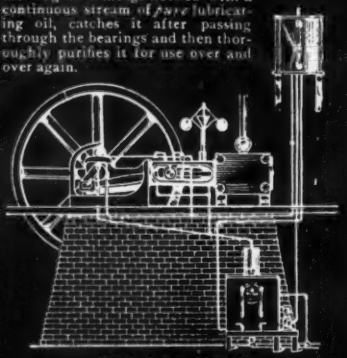

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is the best proof of its money-saving value. Roofs and walls are not showered with wet, oily spray, but instead, the latter is carried down the waste pipe. This Exhaust Head is scientific in principle, noiseless in operation, and very strongly built. Catalog will interest you.

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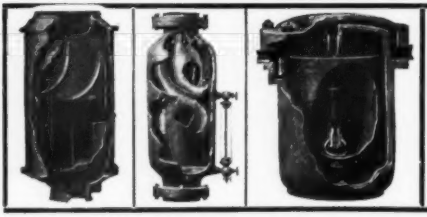

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WRITE FOR TRIAL OFFER
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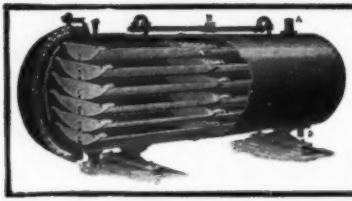

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Live Steam Feed-Water **Purifiers**
Guaranteed to keep boilers clean and free from scale.
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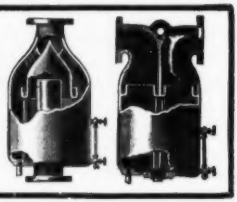
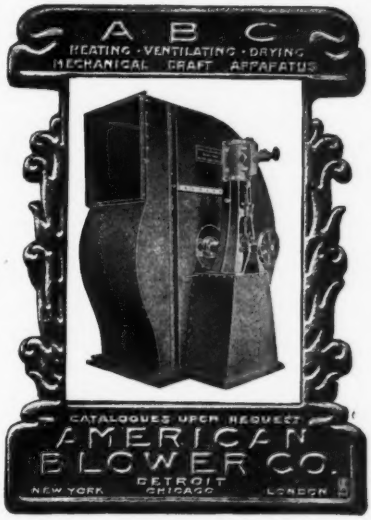
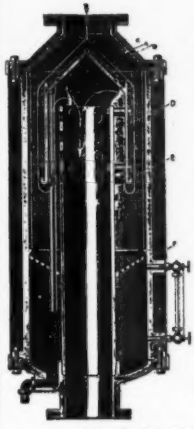




SWEETS SEPARATORS



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Remove all except one-half of 1 per cent. of water.

FOR OIL.

Remove 99 per cent. of it.

We can prove this and give good reasons for it.

In addition they have size and finish.

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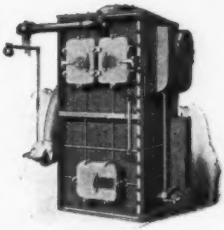
COCHRANE HEATERS

SAVE MONEY



COCHRANE HEATERS save *money* (incidentally they also save labor) by enabling you to utilize your exhaust steam to the best possible advantage—thus doing (with a waste product) work which would otherwise require *live steam* or *coal*. Given sufficient exhaust steam, they will increase the steaming capacity of boilers by feeding the boilers with HOT water—water at 200 or 210 degrees—oftentimes saving the cost of installing new boilers, and the room and attention that new boilers would require. Cochrane Heaters also eliminate contraction and expansion strains on boilers, prolonging the life of the boilers and saving repair bills and the losses resulting from stoppages for repairs.

Cochrane Heaters save labor because of the simplicity of their design and construction, and because of the consequent ease with which they may be operated and cared for. A man can get inside of any Cochrane Heater that is large enough to hold him, and most of the work of cleaning the Heater can be done with a hoe and a hose. The Heater can be cleaned and put back into service in from half an hour to an hour and a half. Compare this with heaters having separate interior compartments, coils or curved tubes, and other inaccessible parts.

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HOLD FAST
BELT DRESSING
makes
BELTS HOLD
16 2/3% BETTER
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MACHINES
and get more power and better service from them by using the

Wear Well Leather Packings
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Plastic Metallic Packing

One style, one size, no rings, no springs, for all pressures. Will not wear or cut rod. Increases efficiency of engine. Reduces friction to a minimum. Retains its plasticity. Never hardens. Always keeps the rod lubricated. Resists extreme temperature. Excellent for steam hammers and Corliss valve stems. Will send a test order on approval to any responsible firm. *Reliable Agents wanted.*

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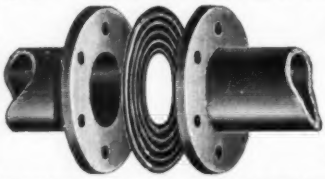
Our Patented Mineral Wool PIPE COVERING and



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Because it will not require frequent taking up and will do its work well.

Our IMPERIAL is that kind of a rubber belt. Made of special extra heavy duck and high grade rubber. The stitches help the rubber in holding the plies together.

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Should be installed in every plant where steam is used

Foster Class "W" Pressure Regulator

maintains a constant high delivery pressure regardless of variation in supply pipes. It can be adjusted according to the pressure to be maintained, and is built without weights, levers, or pistons. It is the standard reducing valve of the United States Navy.

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for pressure up to 15 lbs. delivery and down to 6 inches below atmosphere is the standard for The Webster System of Steam Heating.

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has no direct acting springs or weights—guaranteed not to chatter or hammer. Easily thrown out of service when desired.

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permits the outflow of steam from a boiler and stops the inflow. If one of a battery of boilers were to blow out a cock or tube it would instantly and automatically cut off that boiler from the rest. It never sticks at the vital moment.

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LUNKENHEIMER

on any brass or iron steam specialty corresponds to the "Sterling" mark on silver

VII

Specify LUNKENHEIMER Pop Safety Valves

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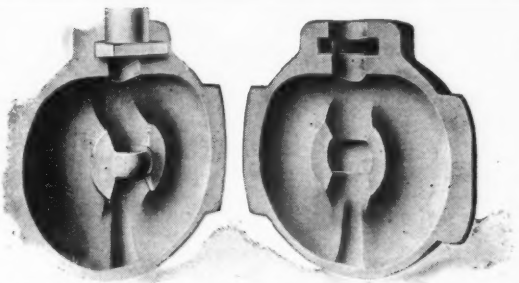

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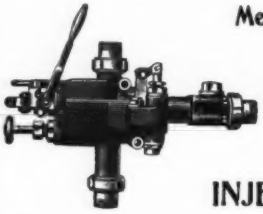

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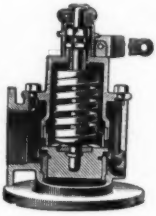

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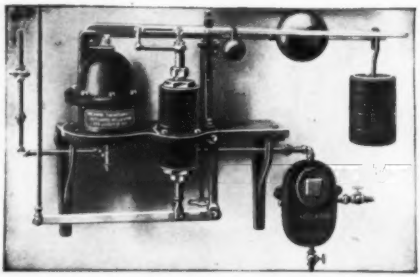

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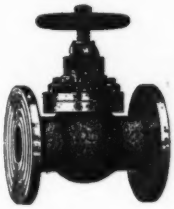

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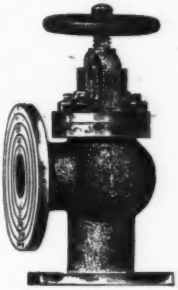

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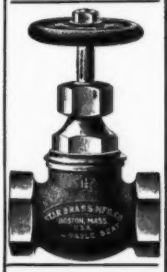

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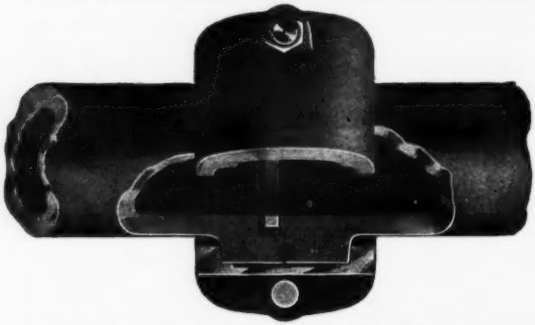

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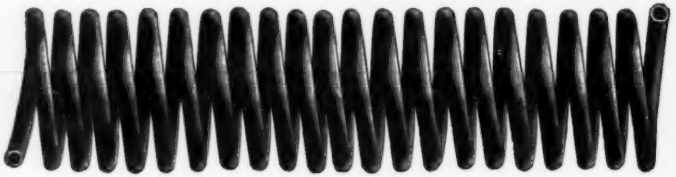

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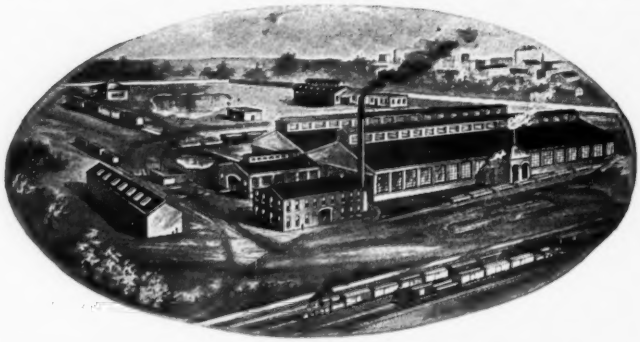

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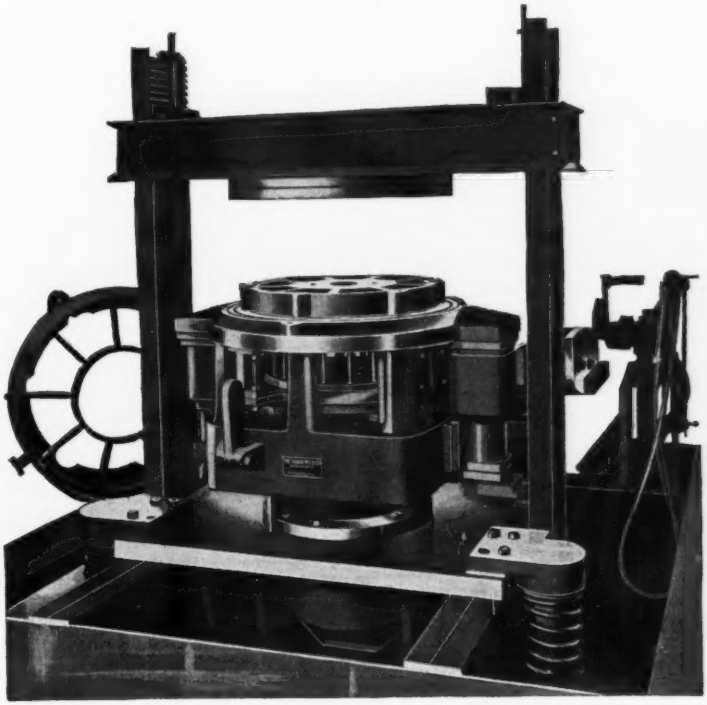

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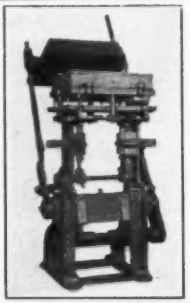

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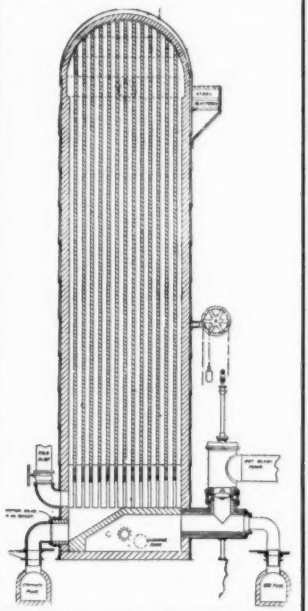

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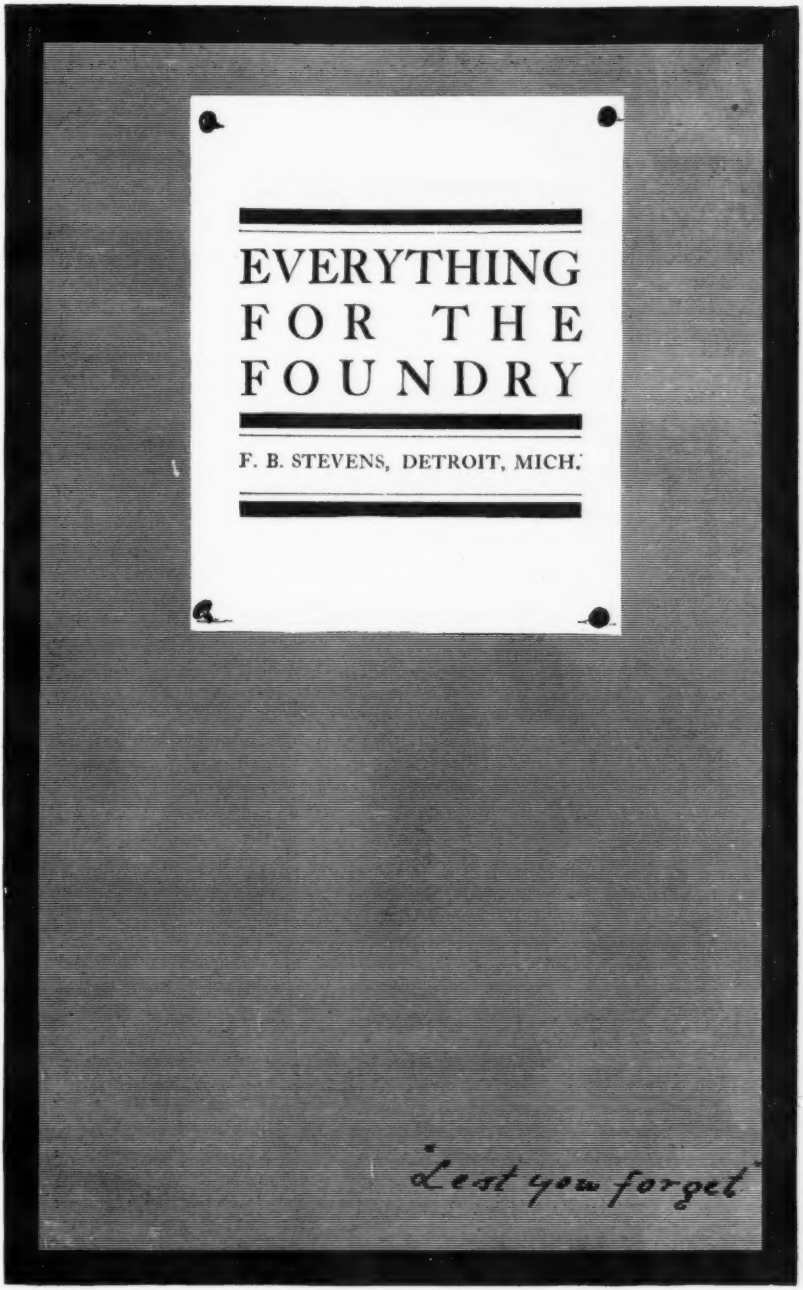
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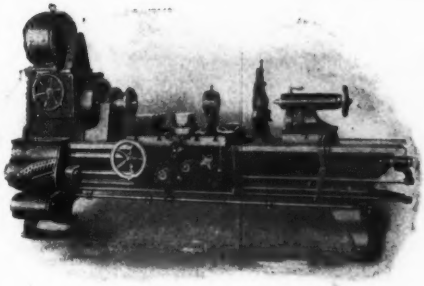

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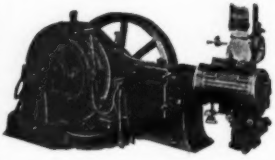

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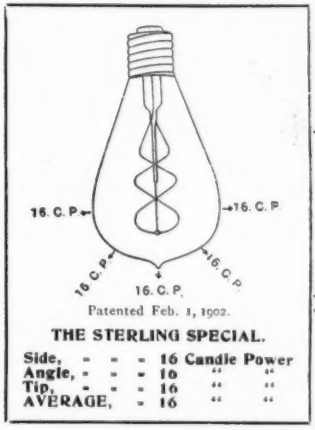

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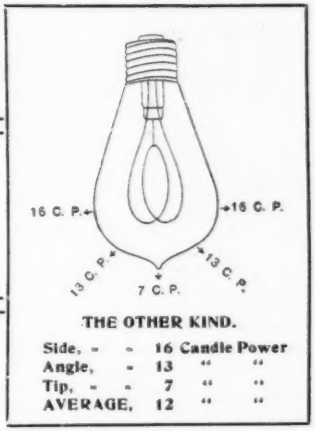

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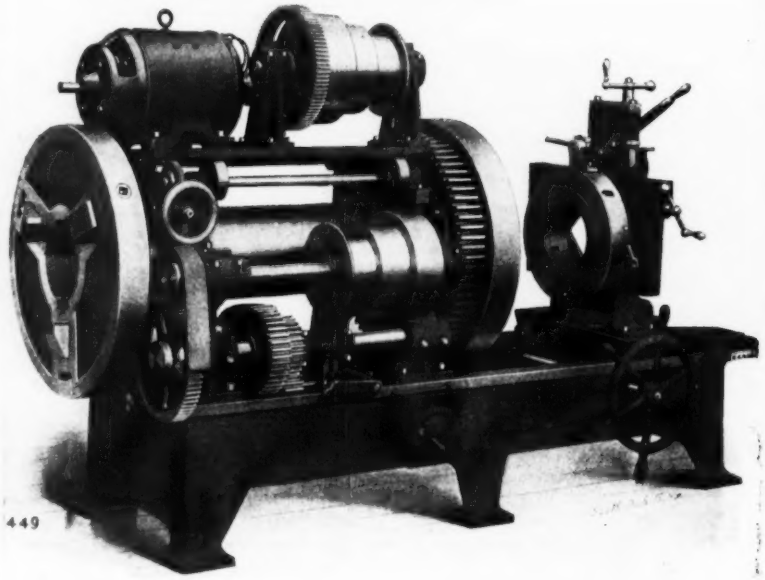

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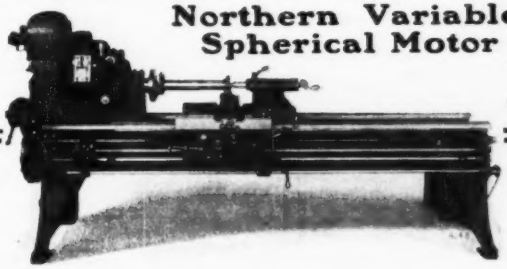

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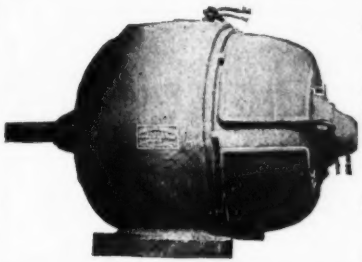

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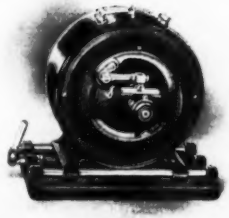

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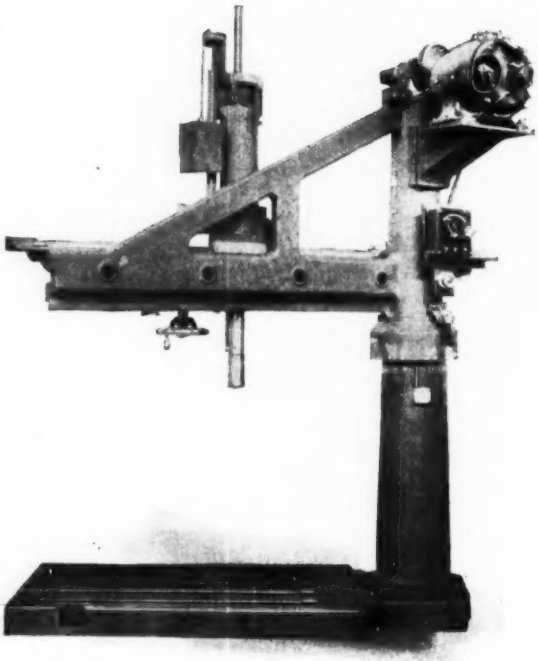

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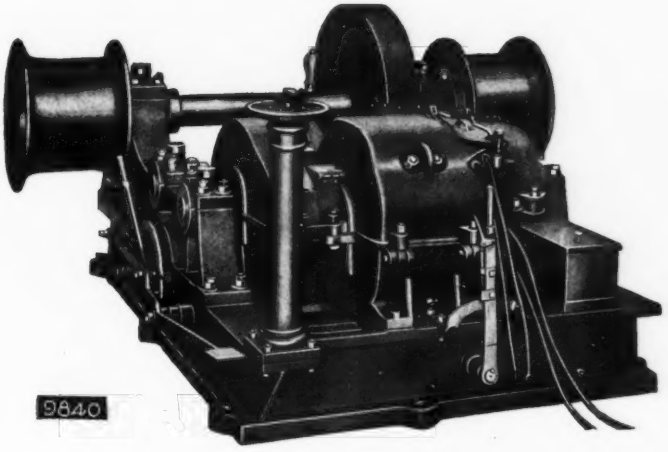

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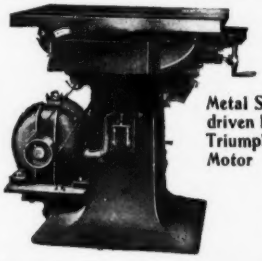

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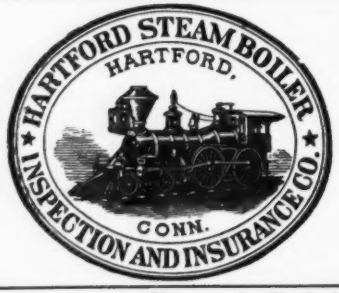

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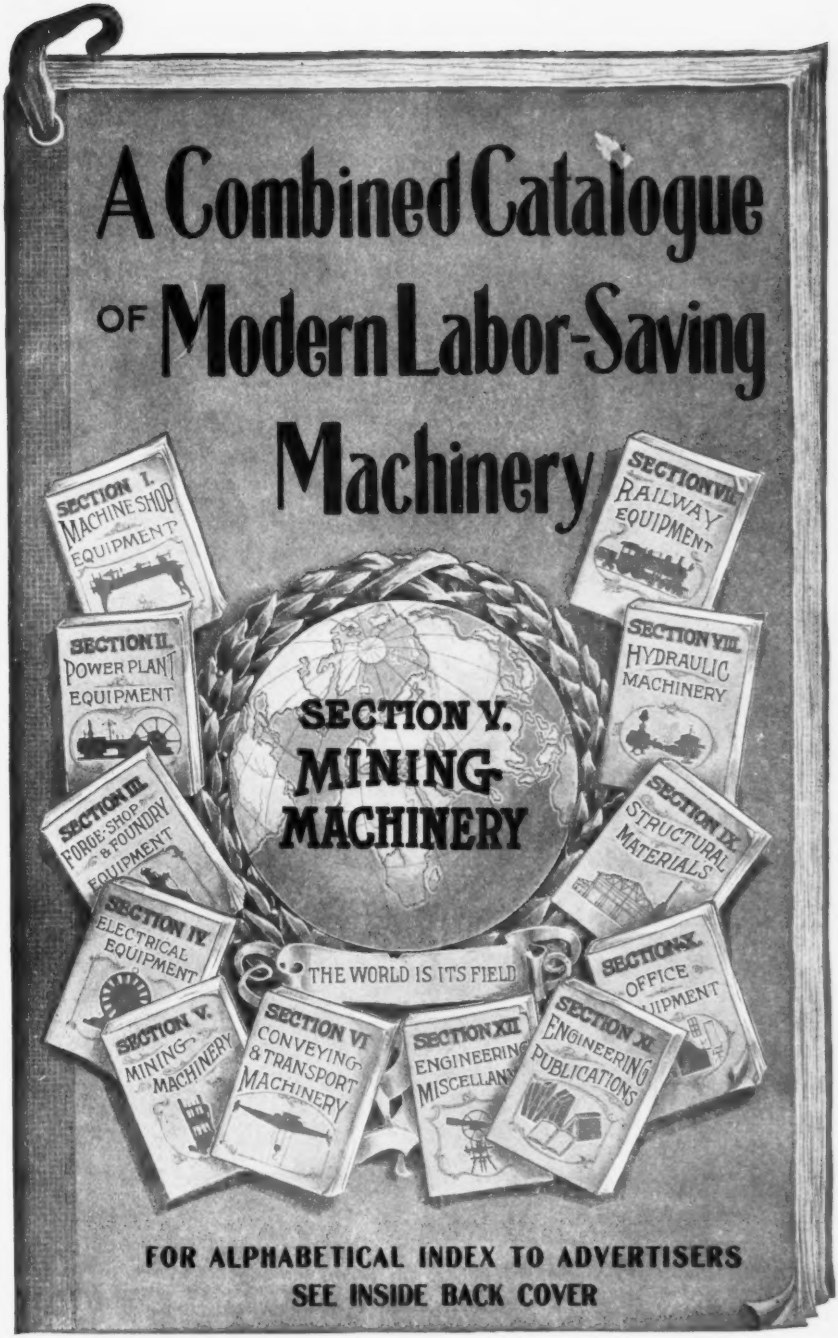
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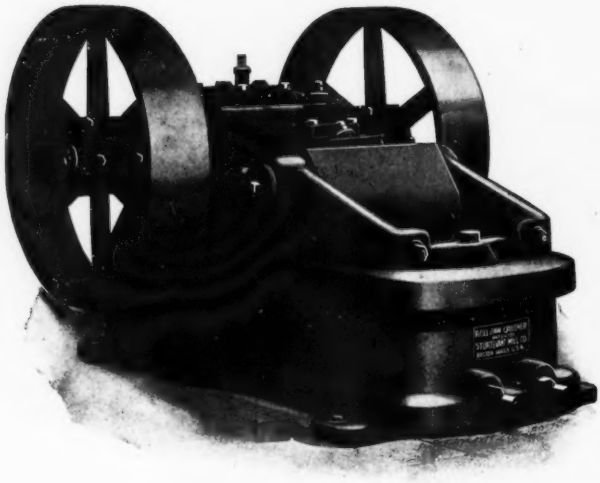

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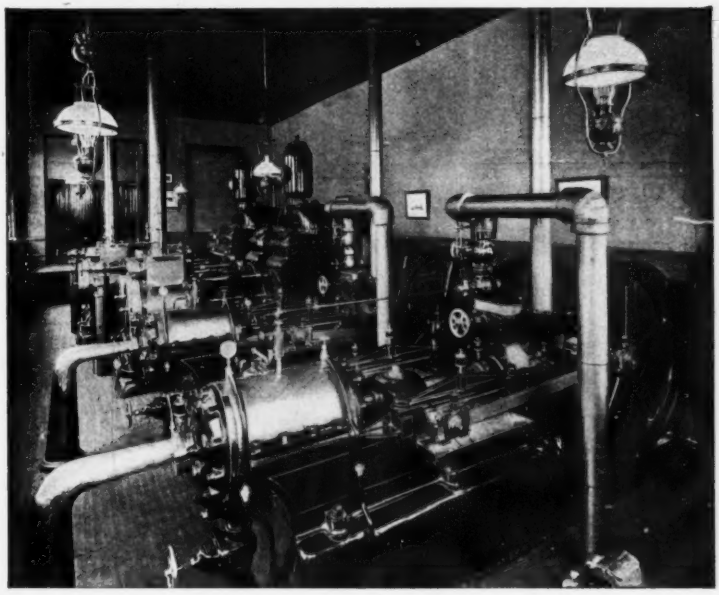

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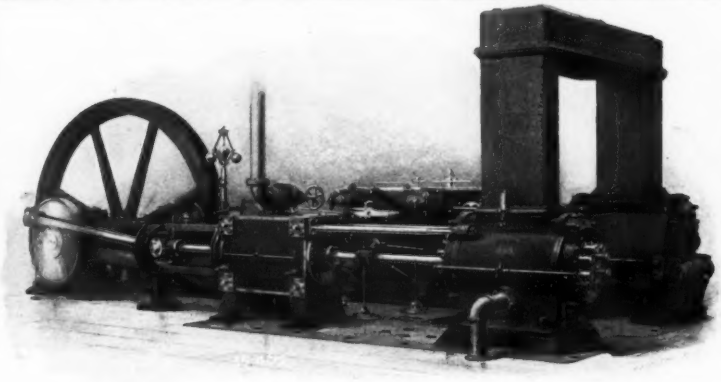

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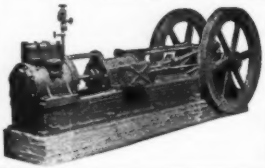

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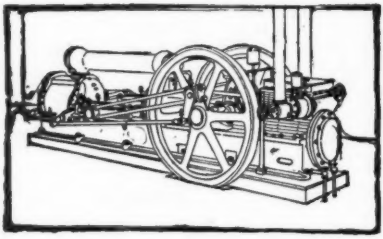

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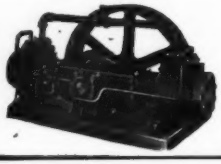

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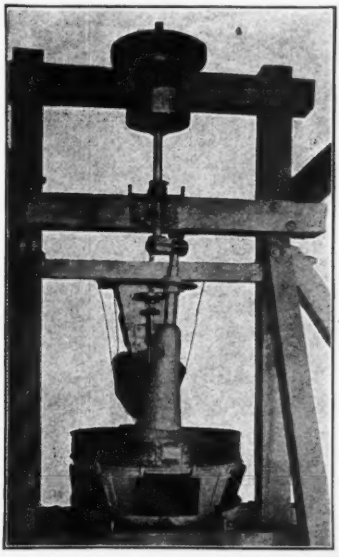

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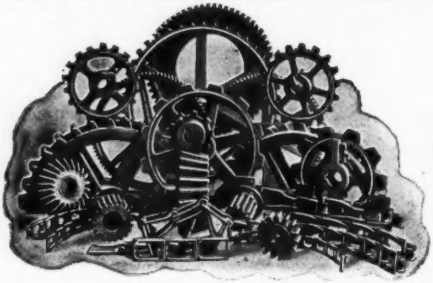

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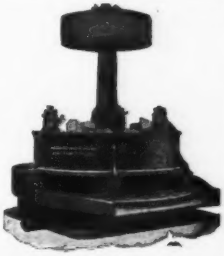
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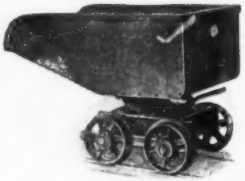

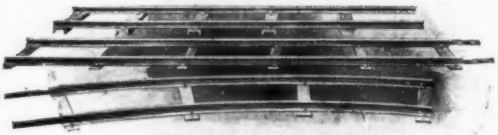

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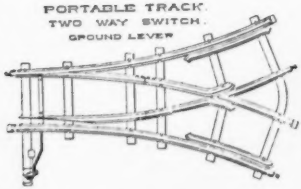

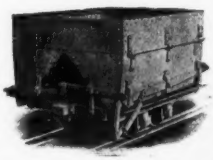

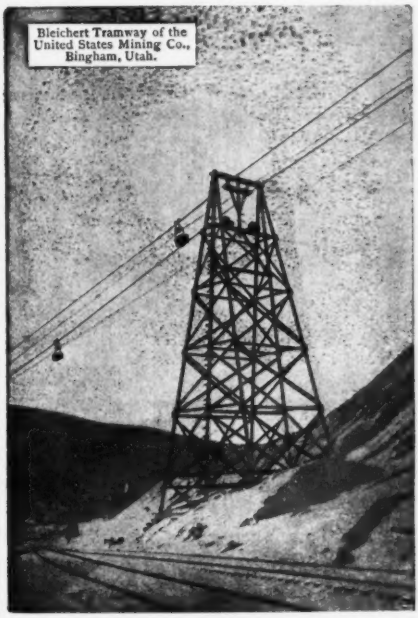
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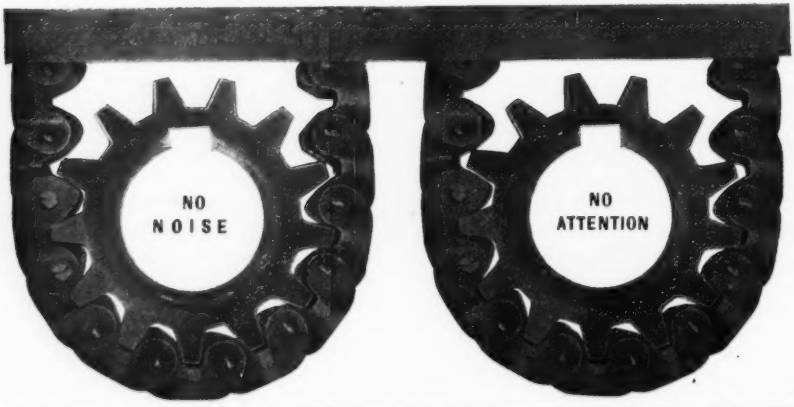

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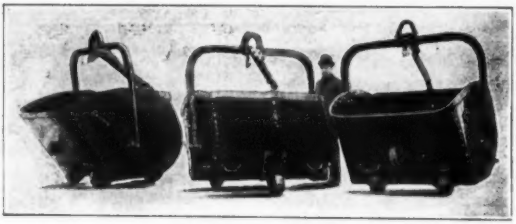

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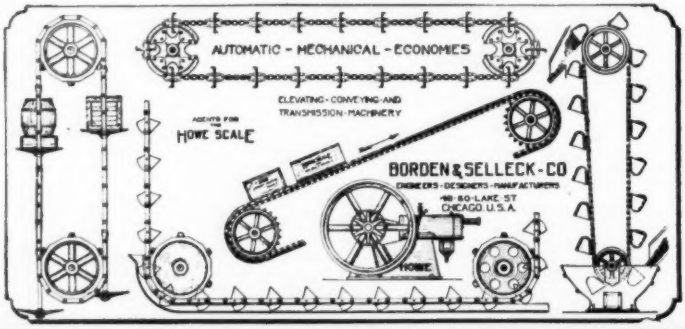
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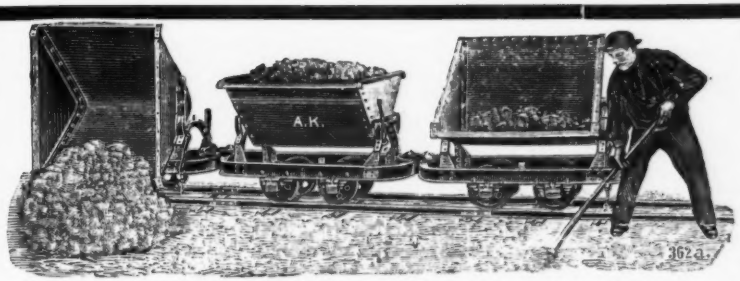

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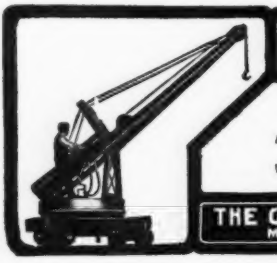

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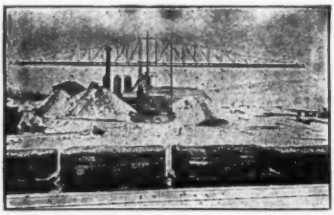

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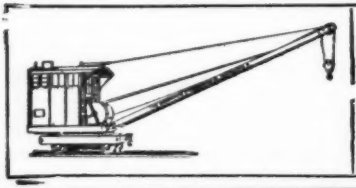

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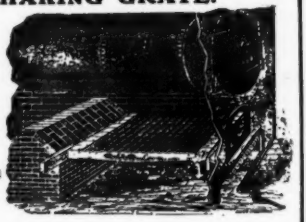

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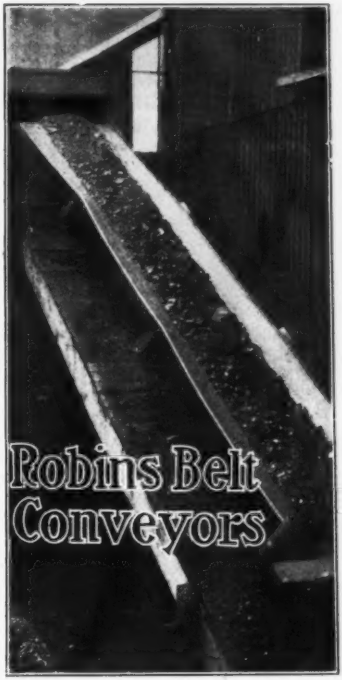

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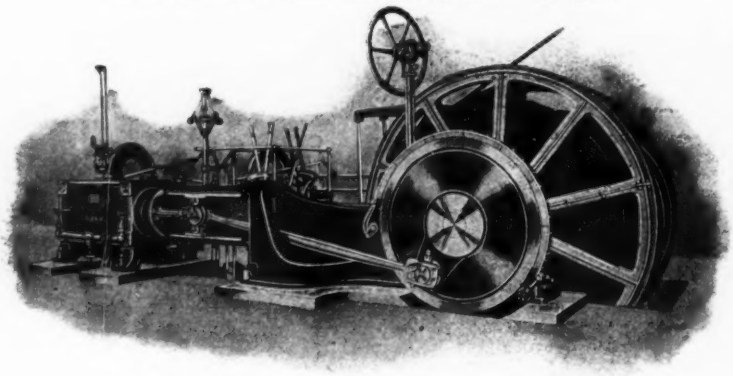

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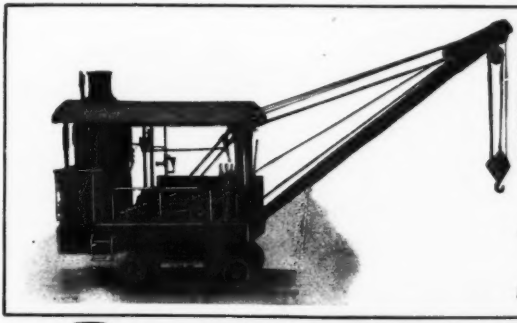

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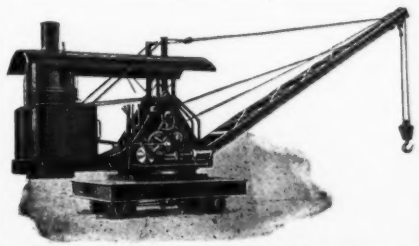

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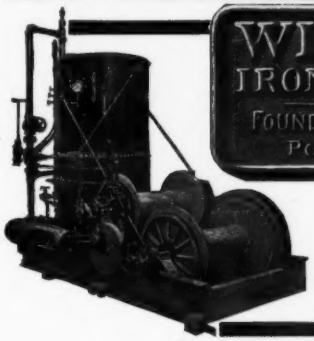

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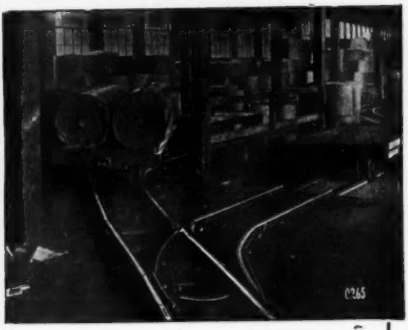

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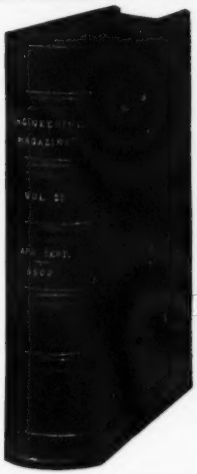

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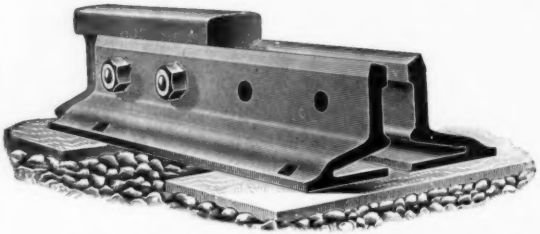

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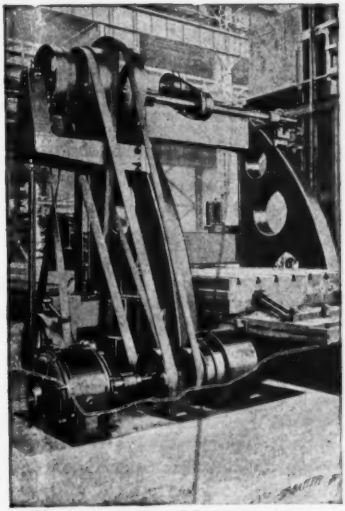

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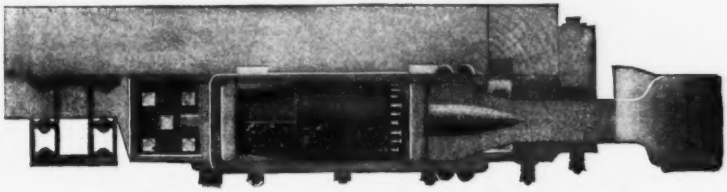

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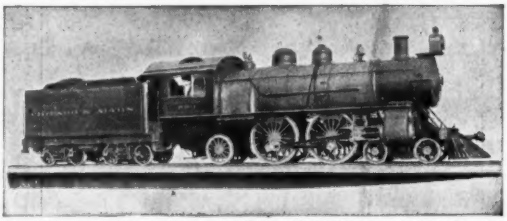

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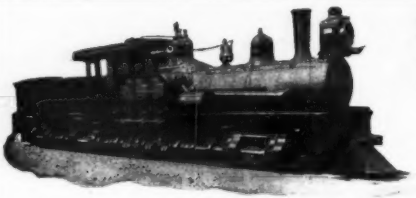

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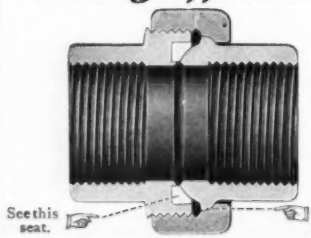

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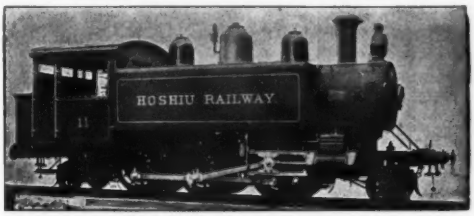

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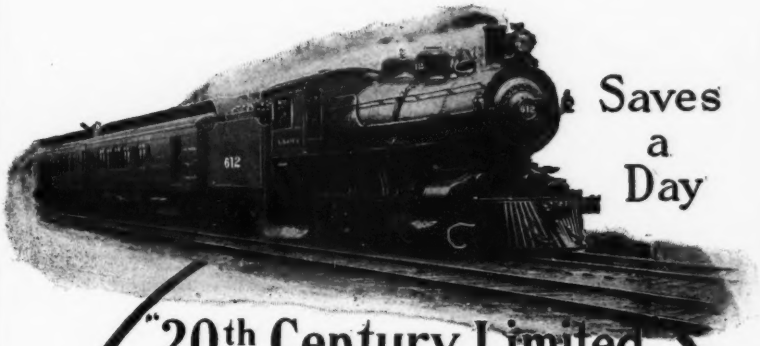

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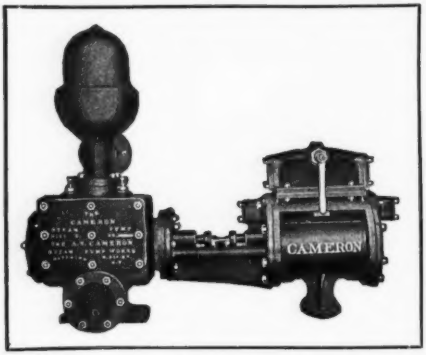

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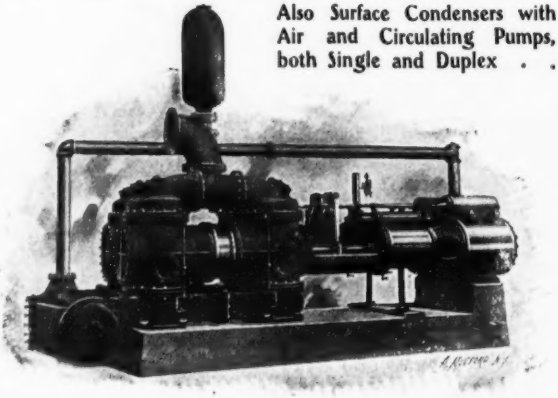

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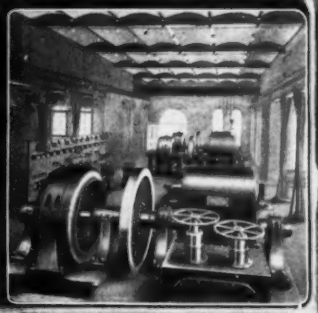

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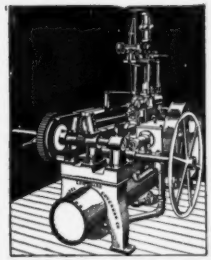

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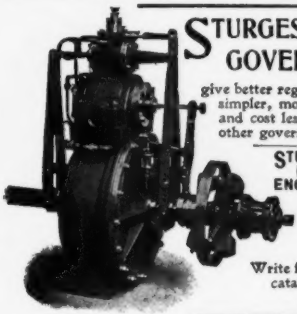

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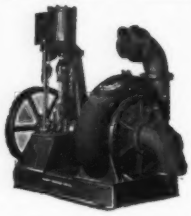

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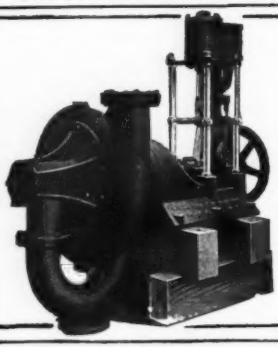

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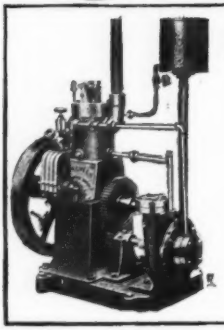

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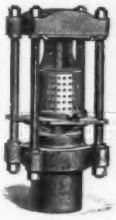

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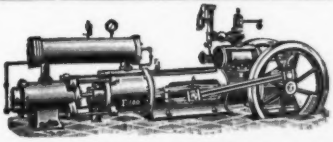

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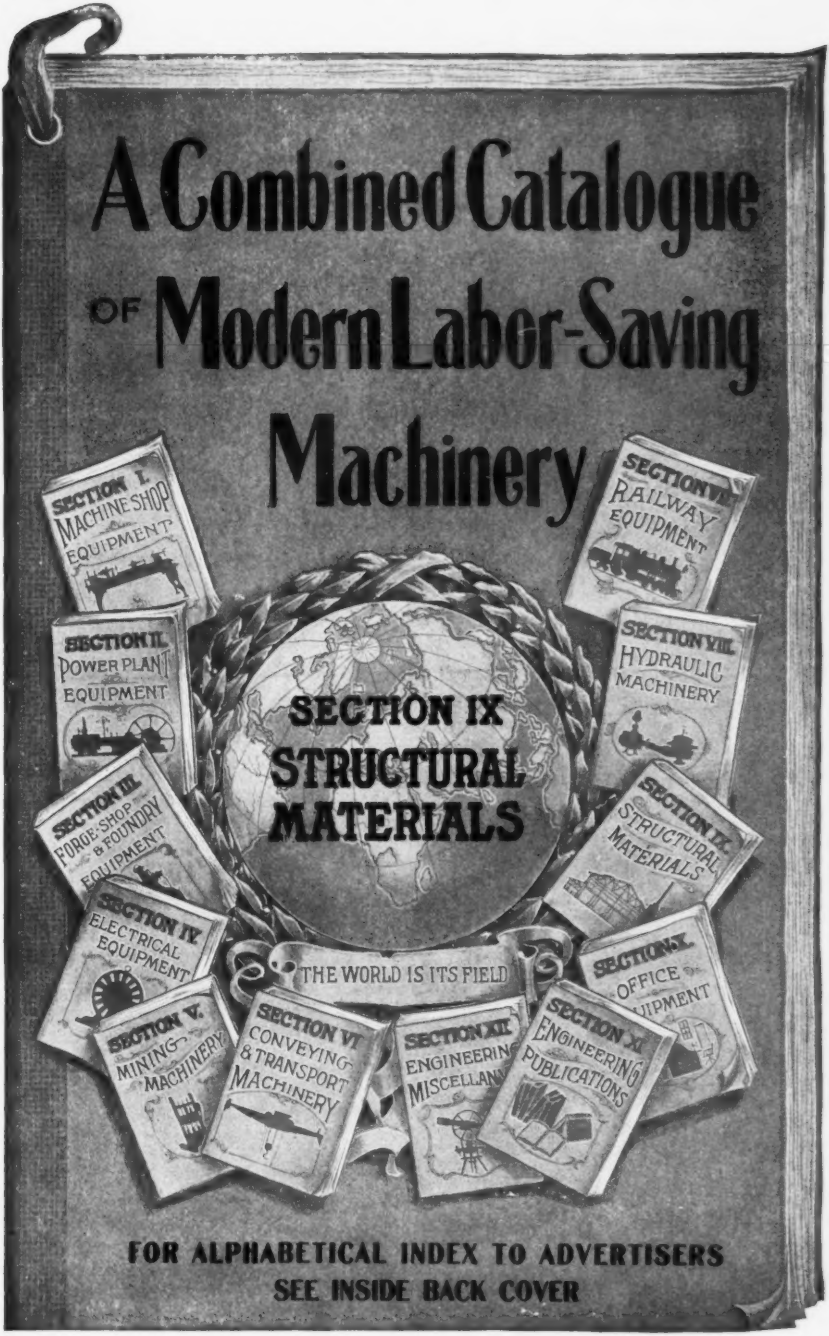

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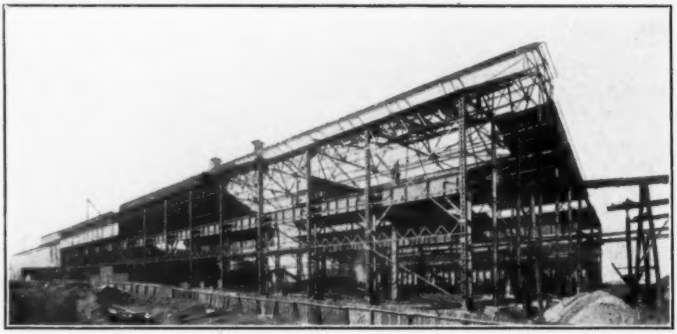

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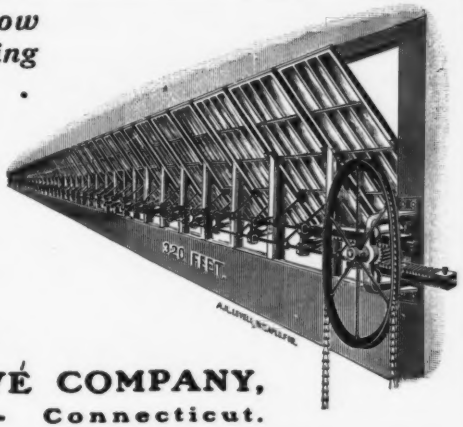

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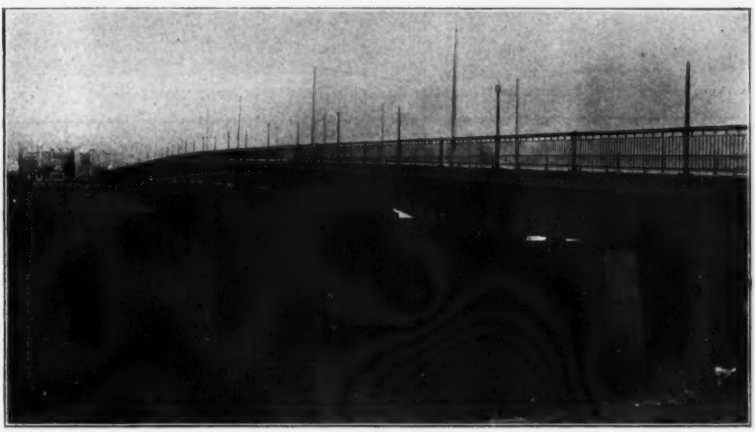

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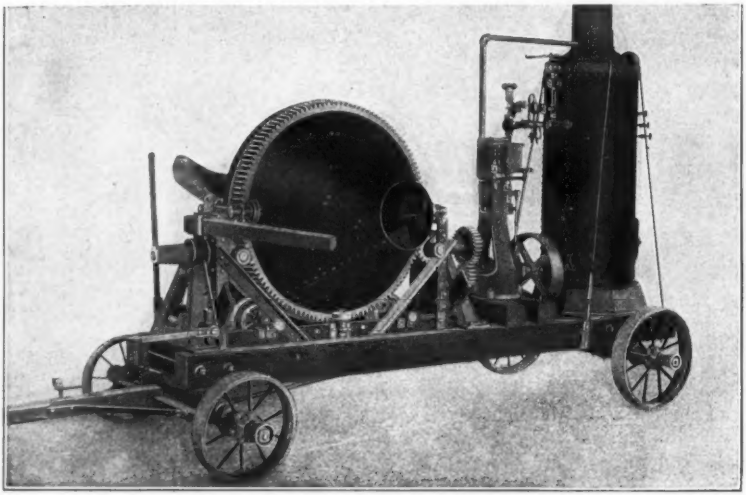

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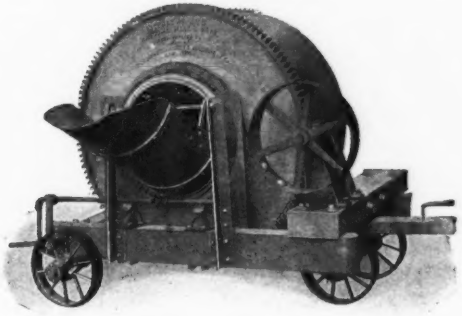

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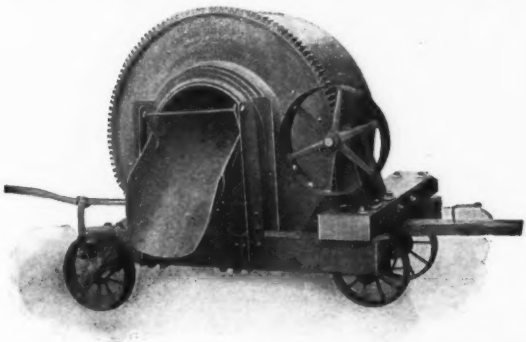

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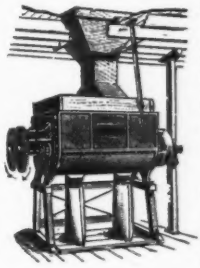

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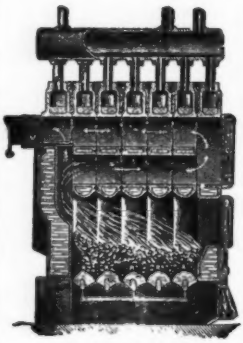

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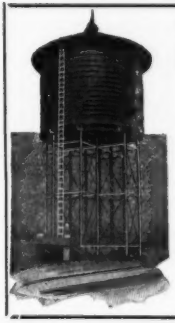

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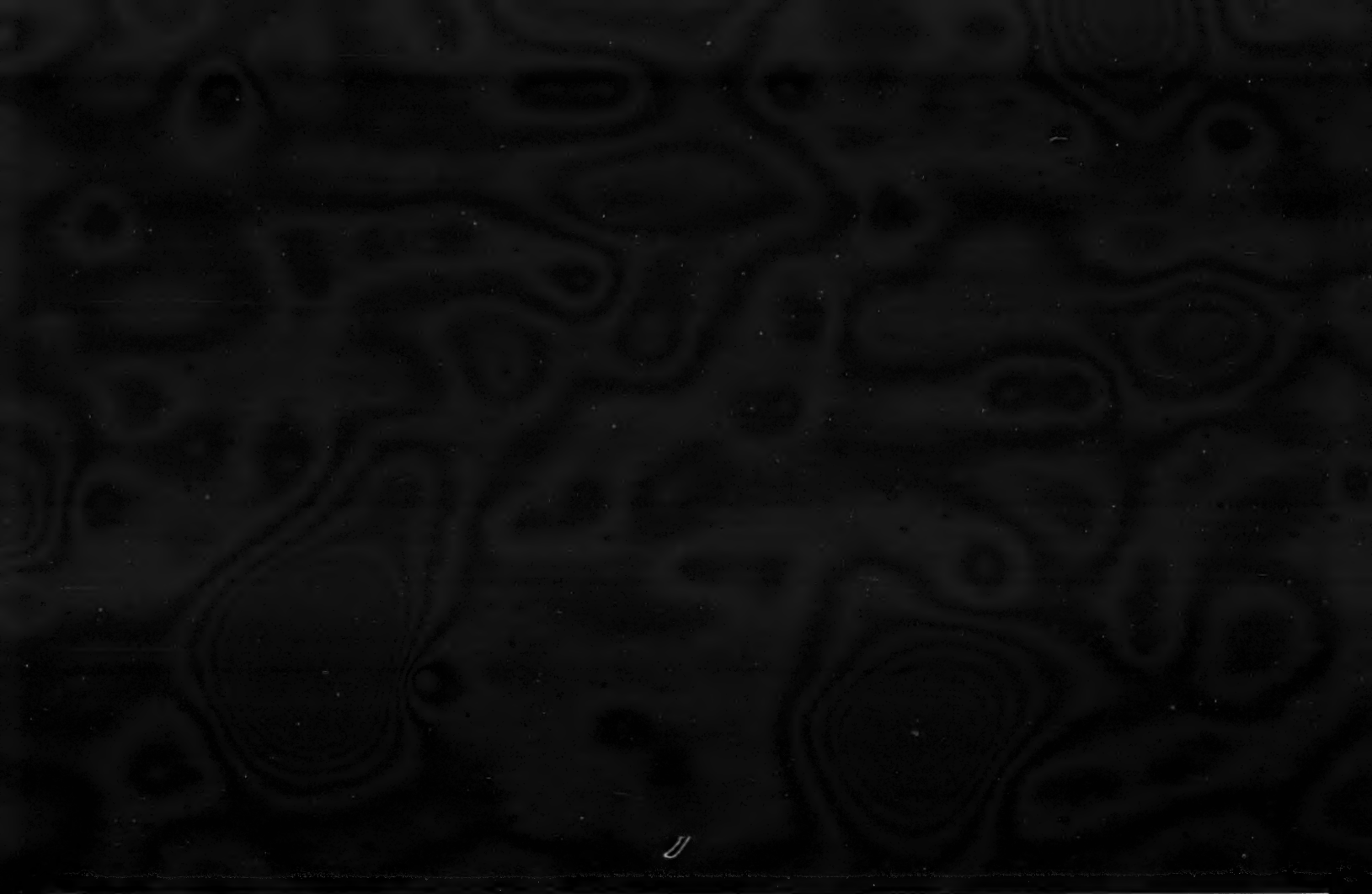

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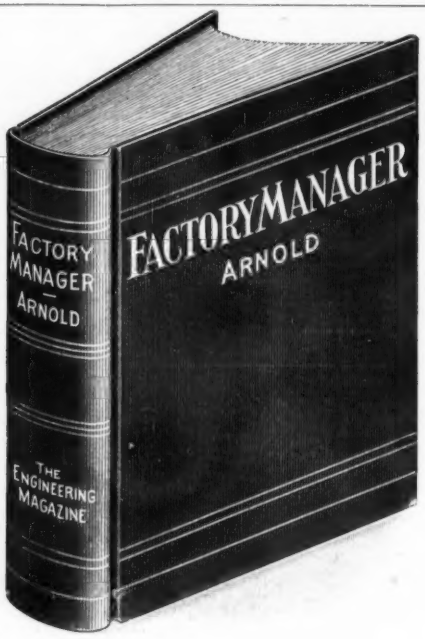

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Itemized cost summary
Sales sheet

Cash received statement
Daily balance sheet
Shipping directions
Correspondence receipts
Order record
Acknowledgment of orders
Pay receipts
Credit memorandum
Advertising department records
Inventory sheet
Voucher registers
Purchase voucher
Purchase voucher remittance slip
Check register
Correspondence
Indexing
Credit form
Traveler's expense weekly statement
Traveler's expense yearly summary
Claim slip for errors
Employment record
Pay rolls and pay envelopes
Pay roll bill and specie specification
Accounting forms
General expense statement

Purchasing Department

Order tracing form
Requisitions and orders
Original and duplicate purchase orders
Quotation card
Departmental purchase requisitions
Purchase order
Purchase vouchers
Supplies urgently required

Drawing Office

Photographic and blue print department requisitions
Special requisition form
Requisition for blue prints
Drawing room time card
Drawings record
Indexing
Drawings issued
Drawings out of place
Blue prints issued

Production Department

Requisitions on foundry, storeroom, pattern shop, drafting office
Work in progress record
Rush order
Inventory card
Regular factory production orders
Color schemes of production orders
Erection tools lists
Bills of material
Typewritten production order
Stockroom production order
Repair orders
Tracers
Spoiled and defective material report
Small orders

Store Room and Tool Room

Stores index cards
Stores replenishment orders
Material returned card
Stores ledger or inventory
Requisition on storeroom
Stores received
Stores rejected
Tool room reports
Tool room charge sheet
Workmen's tool record

Time Records

Outside foreman's report
Outside erecting instructions
Weekly time card—outside workmen
Piece rate card
Piece rate revision card
Piece-work report
Erector's expense account
Miscellaneous time card
Gang time card
Forms for outside use
Piece rate contracts and records
Piece rate notification
Regular and special time charge sheet
Daily time card
Outside work card
Time cards for short operations
Time card sorting boxes

Receiving and Shipping Departments

Shipping report
Notification of shipment to Cost Department, to customer, to Financial Department
Shipping tickets—
"Ready for Shipment" memorandum
Material received records
Material rejected

Miscellaneous Forms

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Watchman's report
Goods returned
Accident report
Outside work, no material
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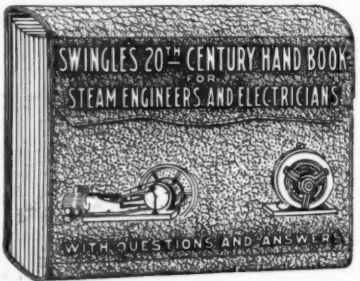

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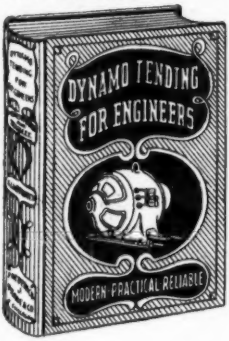

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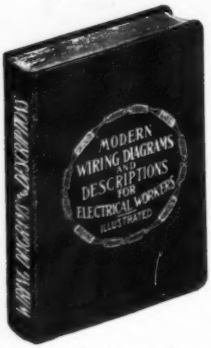

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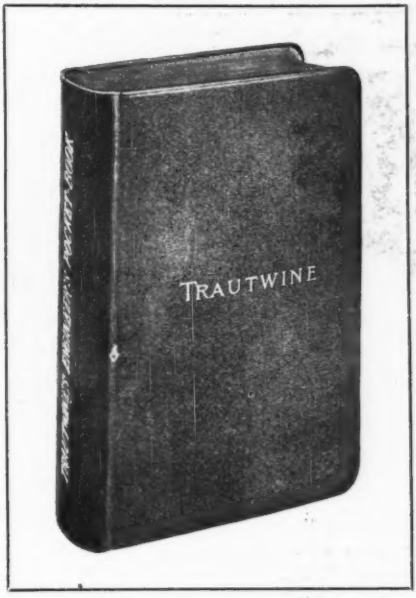

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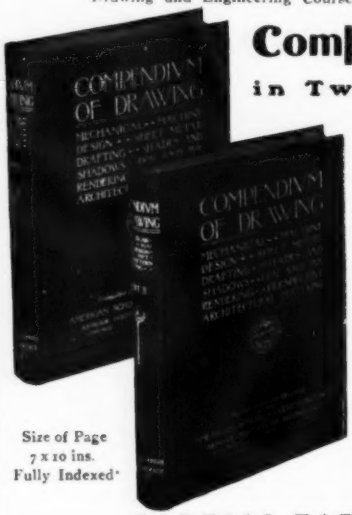

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SECTION III. The Construction of Machine Elements 39-289

Chapter I. Riveting.....39-45
Chapter II. Hooping.....45-47
Chapter III. Keying.....47-50
Chapter IV. Bolts and Screws.50-60
Chapter V. Journals, Lateral and Thrust 66-68
Chapter VI. Bearings, Lateral and Thrust 68-79
Chapter VII. Supports for Bearings 79-84
Chapter VIII. Axles.....84-92
Chapter IX. Shafting.....92-95
Chapter X. Couplings, Rigid, Flexible and Clutch.....95-100
Chapter XI. Simple Levers..101-103
Chapter XII. Cranks.....104-109
Chapter XIII. Combined Levers 110-111
Chapter XIV. Connecting Rods 112-118
Chapter XV. Cross Heads..118-122
Chapter XVI. Friction Wheels 123-126
Chapter XVII. Toothed Gearing 127-150

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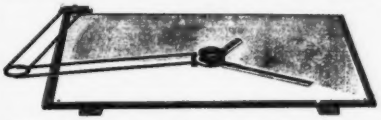

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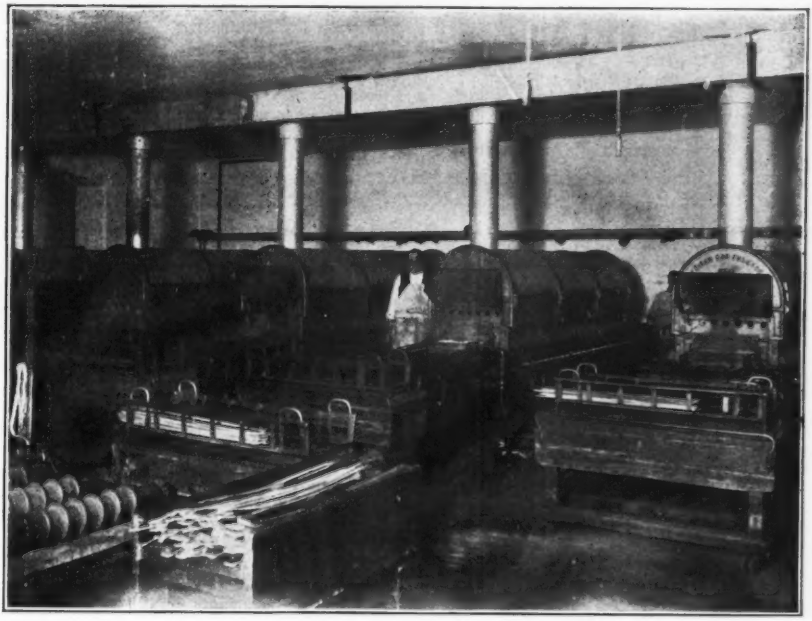

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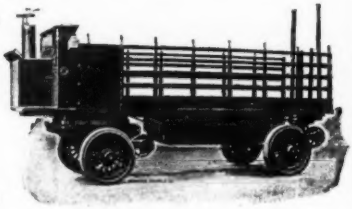

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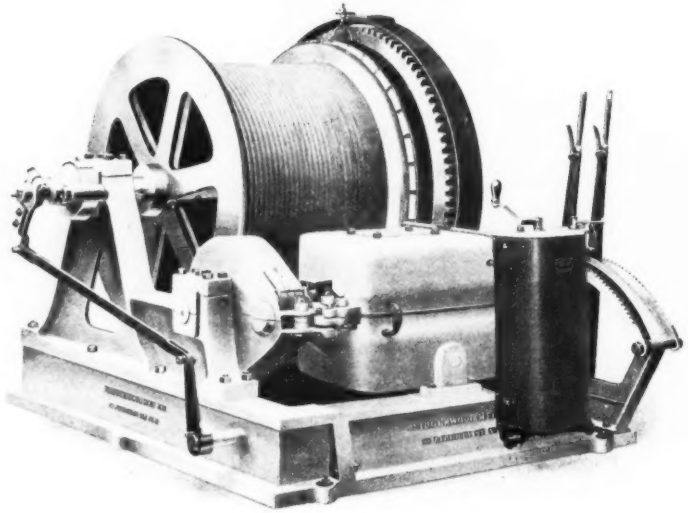

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INDEX TO ADVERTISEMENTS

A

Acme Machinery Co..... 40
Adams Co. 36
Albree Iron Wks., Chester B. 42
Alberger Condenser Co.... 78
Allen Foundry Co. E. R.... 100
Allis-Chalmers Co. 62
Alteneder & Sons, Theo.... 193
Am. Air Compressor Works 122
American Blower Co..... 85
American Bridge Co..... 12
American Cement Co..... 163
American Conduit Co..... 106
Am. Diamond Rock Drill Co. 123
Am. Draft Furniture Co... 193
Am. Electric Improvement Co. 77
American Engine Co..... 66
American Gas Furnace Co. 6-195
Am. Hoist & Derrick Co... 137
Am. Locomotive Co..... 145
American School of Correspondence 182
American Spiral Pipe Works 156
Am. Steam Gauge & Valve Mfg. Co. 30
Am. Tool & Machine Co... 205
American Well Works..... 155
Ashley & Stern..... 198
Ashton Valve Co..... 9
Atlantic, Gulf & Pacific Co. 27
Atlantic Works 73
Atlas Engine Works..... 70
Atlas Portland Cement Co.. 9
Atlas Railway Supply Co... 144
Audel & Co, Theo..... 57
Aultman Co. 136
Austin Separator Co..... 82

B

Babcock & Wilcox Co..... 73
Baird & Co., Henry Carey.. 149
Baker-Vawter Co. 168
Baldwin Locomotive Works 144
Ball Bearing Co..... 54
Ball Engine Co..... 70
Ball & Wood Co..... 67
Bancroft & Co..... 100
Barnes Co., W. F. & John.. 44
Barnet Co., G. & H..... 2
Bartlett & Co., A. F..... 70
Baush Machine Co..... 35
Becker-Brainard Mill. Mch. Co. 36
Benedict & Burnham Mfg. Co. 4
Berlin Construction Co.... 158
Bethlehem Foundry & Machine Co. 55
Bickford Drill & Tool Co... 44
"Big Four" Route..... 146
Bignall & Keeler Mfg. Co.. 38
Bilgram, Hugo 47
Blake Mfg. Co. Geo. F..... 153
Blanchard Machine Co..... 122
Borden & Selleck Co..... 132
Boston Belting Co..... 87
Boston Gear Works..... 47
Bourse, Philadelphia 6
Bradley Mfg. Co..... 64
Brandis Sons Co..... 193
Braun Co., F. W..... 124
Brewer, W. M..... 198
Brill, Geo. M..... 197
Bristol Company 206
Broderick & Bascom Rope Co. 129
Brooklyn Polytechnic Institute 200
Brooks & Co., T. H..... 165
Brown-Corliss Engine Co.. 68
Browning Engineering Co.. 134
Brown Hoisting Machinery Co. 134
Brown & Sharpe Mfg. Co.. 26
Bucyrus Co. 4
Buffalo Foundry Co..... 100
Buff & Buff Mfg. Co..... 193
Buhl Malleable Co..... 0
Bullard Machine Tool Co.. 37
Bullock Elec. Mfg. Co..... 108

C

C & C Electric Co..... 106
Cabot, Samuel 159
Cahall Sales Dept..... 72
Calculagraph Co. 168
Caldwell & Son Co., H. W. 47
Caldwell & Co., W. E..... 165
Cameron Steam Pump Wks., A. S. 152
Carborundum Co. 46
Card & Weber Mch. Co.... 123
Case Mfg. Co..... 134
Catlett, Chas. 198
Chicago & Alton R'way Co. 149
Chicago, Mil. & St. Paul Ry. 148
Clarkson School of Technology 200
Clayton Air Compress. Wks. 122
Cleveland Punch & Shear Works 43
Cobb, Edward S..... 198
Coburn Trolley Mfg. Co... 95
Coes Wrench Co..... 55
"Compressed Air" 90
Consolidated Safety Valve Co. 90
Continental Iron Wks..... 205
Continuous Rail-Joint Co. of America 142
Contractor's Plant Mfg. Co. 134
Contractors Supply & Equipment Co. 160
Cost System & Auditing Co. 11
Cox & Sons Co..... 41
Crane Co. 66-91
Crocker-Wheeler Co. 105
Crosby Steam Gauge & Valve Co. 3
Cumberland Steel Co..... 46
Curtis & Curtis Co..... 43
Curtis & Curtis Mfg. Co.... 49
Cutler-Hammer Mfg. Co... 115
Cutter Co. 30

D

Dallett & Co., Thos. H..... 28
Darling, L. B..... 198
Dart Mfg. Co., E. M..... 84
Davis Co., John..... 82
Davis Regulator Co..... 81
Dayton Globe Iron Wks. Co. 3
Deane Steam Pump Co.... 156
D., L. & W. R. R..... 194
Denver & Rio Grande Ry... 148
Derry-Collard Co. 179
D'Este Co., Julian..... 80
De Nyse & Sons, Wm..... 196
Detroit Graphite Mfg. Co... 30
Detroit Leather Specialty Co. 86
Diamond Drill & Mach. Co. 41
Diemer, Hugo 198
Dieterich, C. A..... 198
Ditzgen Co., Eugene..... 193
Dingee, M. H. 99
Direct Separator Co..... 85
Dixon Crucible Co., Joseph 9-96
Doble, Robert McF..... 198
Dodge & Day..... 199
Drake & Co., F. J..... 180
Drouvé Co., G..... 159
Dunning, W. D..... 163
Durant Co., The W. N..... 168

E

Eagle Oil & Supply Co..... 86
Edison Portland Cement Co. 162
Electric Vehicle Co..... 196
Engineering Agency 199
Engineering Co. of Am.... 30
Epping-Carpenter Co. 152
Ericsson Telephone Co..... 6
Erie R. R..... 148
Eureka Fire Hose Co..... 205
Evans-Wilkins Co. 193

F

Fairbanks, Morse & Co..... 30
Fay & Egan, J. A..... 52
Fay & Scott..... 45
Federal Manufacturing Co. 54
Flagg & Co., Stanley G.... 206
Flint & Walling Mfg. Co... 165
Foster Mfg. Co., F. W..... 89
Foster Engineering Co..... 88
Frank Machinery Co..... 52
Frick Co. 74

G

Garrison Foundry Co., A... 100
Garry Iron & Steel Co..... 134
General Electric Co.....110-113
General Pneumatic Tool Co. 42
General Power Co..... 2
Globe Mch. & Stamping Co., 41-98
Globe-Wernicke Co. 169
Goepel & Niles..... 197
Goubert Mfg. Co..... 82
Gradstone & Co., M..... 27
Green Fuel Economizer Co. 76
Griffing Iron Co., A. A.... 80
Guarantee Electric Co..... 116
Guild & Garrison..... 32
Gunn-Richards Co. 10-197

H

Hall Steam Pump Co..... 122
Hammel, C. A..... 145
Harron, Rickard & McCone 125
Harrisburg Foundry & Mch. Works 69
Harrison Safety Boiler Wks. 85
Hartford Steam Boiler Inspection & Ins. Co..... 116
Harvard University 200
Hayden & Derby Mfg. Co.. 90
Hayward Co. 205
Heine Safety Boiler Co.... 72
Hendrie & Bolthoff Mfg. & Supply Co. 125
Henshaw, Bulkley & Co.... 123
Hercules Gas Engine Works 154
Herron & Bury Mfg. Co... 122
Hess Machine Co..... 36
Hileman-James Co. 86
Hilles & Jones Co. 43
Hisey-Wolf Machine Co... 51
Hohmann & Maurer Mfg. Co. 3
Holt & Schober..... 198
Hooven, Owens, Rentschler Co. 66
Hoppes Mfg. Co..... 84
Howard Iron Works..... 34
Hudson Engineering & Contracting Co. 199
Hunt Co., C. W..... 138
Hunt & Co., Robt. W..... 197

I

Illinois Central R. R..... 148
Imhauser & Co., E..... 3
Industrial Works 137
Ingersoll-Sergeant Drill Co. 119
Irwin Machinery & Supply Co., E. W..... 49

J

Jantz & Leist Electric Co... 109
Jefferson Mfg. Co..... 144
Jeffrey Mfg. Co..... 135
Jenkins Bros. 206
Jessop & Sons, Wm., Ltd... 51
Jones & Lamson Mch. Co... 44
Jour. Assn. Eng. Societies.. 28

K

Kansas University 201
Kelley Island Lime & Transport Co. 163
Kennedy, Julian 199
Kennedy, Walter 197
Kennedy Valve Mfg. Co... 89
Keuffel & Esser Co..... 193
Keystone Drop Forge Wks. 27
Kilbourne & Jacobs Mfg. Co. 10

INDEX TO ADVERTISEMENTS

Kingsford Fdy.& Mch. Wks. 154
Kinnear Mfg. Co..... 30
Kloman Co., Inc..... 99
Knowles Steam Pump Wks. 154
Koppel, Arthur 133
Koven & Bro., L. O..... 78

L

Lacy Mfg. Co..... 156
Lafayette College 201
Laidlaw-Dunn-Gordon Co... 154
Lake Shore R. R..... 147
Lambert Hoisting Engine Co. 137
Landis Tool Co..... 40
Latrobe Steel Co..... 100
Lawrence Cement Co..... 206
Lawrence Scientific School. 200
Lehigh University 200
Leschen & Sons Rope Co.,A. 133
Lewis Institute 200
Lidgerwood Mfg. Co.....32-202
Lima Locomotive & Machine Co. 144
Link-Belt Engineering Co.. 131
Lombard Governor Co..... 153
Lubrication Publishing Co.. 36
Lunkenheimer Co. 89
Lyon & Co., J. D..... 90
Lyon Metallic Mfg. Co..... 41

M

Mabbs Hydraulic Packing Co. 91
McCabe & Co., P. B..... 123
McClure, Son & Co., G. W. 197
McGill University 201
McGowan Co., John H..... 155
McNab & Harlin Mfg. Co.. 91
Machinery & Electrical Co.. 125
Manning, Maxwell & Moore 90
Marion Steam Shovel Co... 3
Maryland Steel Co..... 8
Mass. Inst. of Technology.. 200
Maurer & Son, Henry..... 11
Mead Mfg. Co., Jonn A.... 135
Merritt & Co..... 53
Michigan College of Mines 200
Michigan Pipe Co..... 156
Mietz, A. 69
Miller & Franklin Co..... 198
Minneapolis Steel & Mchy. Co. 74
Moore & Co., Chas. C..... 81
Moran Bros. 90
Morgan Construction Co... 198
Morris, P. H..... 3
Morris Machine Works..... 154
Morse Chain Co..... 130
Morse Twist Drill & Machine Co. 9
Morse Elevator Works..... 54

N

National Acme Mfg. Co.... 39
National Electric Co..... 106
National Fireproofing Co... 164
National Machinery Co..... 49
National Pipe Bending Co.. 81
New Process Rawhide Co.. 47
New York Central R. R.... 149
New York Continental Jewell Filtration Co..... 6
Niagara Mch. Tool Wks.... 4
Nicholson File Co..... 2
Niles-Bement-Pond Co. 29
North Electric Co..... 114
Northern Elec. Mfg. Co... 109
Norwalk Iron Works Co... 122
Norwich University 201
Nuttall Co., R. D..... 47

O

Obermayer Co., S..... 94
Oglesby, Milton L..... 198
Orford Copper Co. 12

P

Palmer, W. K..... 197
Paraffine Paint Co..... 163
Parson Mfg. Co..... 76
Patent Record 198
Patterson Tool & Supply Co. 52
Pelton Water Wheel Co.... 153
Penna. Military College.... 201
Penna. Silica Brick & Mfg. Co. 164
Penna. State College..... 201
Pennsylvania Steel Co..... 8
Pennsylvania University ... 200
Phila. Pneumatic Tool Co.. 42
Phillips Mine & Mill Supply Co. 124
Phosphor Bronze Smelt. Co. 98
Pierce Co., Wm. B..... 75
Pittsburg Blue Print Co.... 192
Pittsburg Boiler Scale Resolvent Co. 73
Pittsburg Gage & Supply Co. 84
Pittsburg Valve, Foundry & Construction Co 98
Poole Eng. & Mach. Co.... 55
Porter & Co., H. K..... 145
Potter-Johnston Mch. Co... 48
Power and Mining Machinery Co. 71
Power Installation Co..... 197
Power Specialty Co..... 6
Power & Speed Controller Co. 50
Pratt Institute 201
Pratt & Whitney Mfg. Co.. 28
Providence Eng'ng Works.. 66

Q

Quimby, Inc., Wm. E..... 10
Quincy Engine Works..... 4

R

Rand Drill Co.....120-121
Ransom Concrete Mchy. Co. 161
Reeves Engine Co..... 70
Reeves & Son, Paul S..... 100
Rensselaer Polytechnic Inst. 201
Riter-Conley Mfg. Co..... 11
Robins Conveying Belt Co.. 135
Robbins & Myers..... 109
Robinson, A. W..... 197
Roebling Construction Co... 27
Roelker, H. B..... 197
Roessler & Hasslacher Chemical Co. 124
Rogers Locomotive Works.. 145
Rose Polytechnic Institute.. 200
Ross & Co..... 74
Ross Valve Co..... 83
Rotary Engine Co..... 65

S

Sage, Chas. S..... 198
St. John Grate Bar Co..... 134
Scaife & Sons Co., Wm. B.. 78
Schieren & Co., Chas. A.... 60
Scranton & Co..... 53
Sellers & Co., Wm..... 43
Shaw, E. M..... 100
Sheffield Scientific School.. 200
Shepherd Engineering Co.. 63
Silicate Stone Co..... 164
Simmons Co., John..... 92
Simplex Electric Heating Co. 116
Skinner Engine Co..... 67
Smidth & Co., F. L..... 125
Smith Co., H. B..... 164
Snow Steam Pump Works.. 154
Southern Pacific Co..... 150
Southwark Fdy. & Mch. Co. 63
Sprague Electric Co..... 104
Standard Diamond Drill Co. 123
Standard Gauge Mfg. Co.. 78
Standard Paint Co..... 165
Standard Tool Co..... 55
Star Brass Mfg. Co..... 91
Steptoe Shaper Co., John... 49
Sterling Electrical Mfg. Co. 107
Sterling Varnish Co..... 10
Stevens, F. B..... 101
Stevens Inst. of Technology 201
Stewart Heater Co..... 83
Stirling Co. 73
Stockbridge Machine Co... 49
Stow Flexible Shaft Co.... 51
Stow Manufacturing Co.... 42
Stroud & Co., E. H..... 4
Struthers-Wells Co. 69-72
Steubner, G. L..... 132
Sturgess Governor Engineering Co. 153
Sturtevant Co., B. F..... 79
Sturtevant Mill Co..... 118

T

Tabor Mfg. Co..... 97
Taylor Iron & Steel Co.... 124
Tengwall File & Ledger Co. 168
Thompson Co., Richard.... 90
Tod Co., Wm. 67
Townsend, David 197
Tracy Engineering Co..... 84
Trenton Iron Co..... 129
Triumph Electric Co..... 116
Tufts College 201
Turner Machine Co..... 98
Turner, Vaughn & Taylor Co. 199

U

Underwood & Co., H. B.... 43
U. S. Cast Iron Pipe & Foundry Co. 156
U. S. Mineral Wool Co.... 86
U. S. Wind Engine & Pump Co. 165
Universal Drafting Machine Co. 193

V

Vermont University 201
Vulcan Iron Works (Chicago) 163
Vulcan Iron Works (San Francisco) 66
Vulcan Iron Works Co. (Toledo) 6

W

Walworth Mfg. Co..... 9
Ward-Leonard Electric Co.. 116
Warren Bros. Co..... 206
Waterbury Farrel Foundry and Machine Co..... 44
Watson-Stillman Co. 155
Watson & McDaniel Co.... 80
Watt Mining Car Wheel Co. 2
Weber Gas & Gasoline Engine Co. 69
Webster, Camp & Lane Co. 136
Webster & Co., Warren.... 83
Wellman-Seaver-Morgan Co. 136
Westinghouse Air Brake Co. 143
Westinghouse Electric & Mfg. Co. 143
Westinghouse Machine Co.. 60
Weston Electric Instmt. Co. 32
Wetherill & Co., Robt..... 63
Wheeler Condenser & Engineering Co. 78
Wickes Bros. 72
Wiley & Sons, John..... 181
Willamette Iron & Steel Wks. 137
Williams, Brown & Earle... 193
Williams Bros. 165
Wisconsin University 200
Wonham-Magor Eng'g Wks. 128
Woodward Governor Co..... 153
Wood & Co., R. D..... 51
Worcester Polytechnic Institute 201
Worthington, Henry R..... 156
Wright Mfg. Co.....80-84
Wyman & Gordon..... 206

Y

Yale University 200

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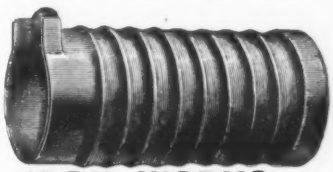

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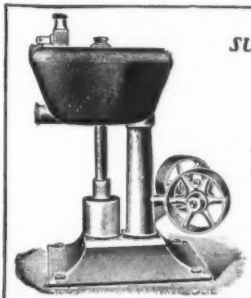

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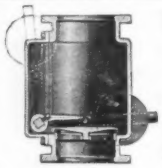

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